

Environmental Security Technology Certification Program (ESTCP)



FINAL LABORATORY TREATABILITY REPORT FOR: Emulsified Zero Valent Iron Treatment of Chlorinated Solvent DNAPL Source Areas

ESTCP Project CU-0431

**23 January 2006
Revision 1.0**

Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE 23 JAN 2006		2. REPORT TYPE		3. DATES COVERED 00-00-2006 to 00-00-2006	
4. TITLE AND SUBTITLE Final Laboratory Treatability Report for: Emulsified Zero Valent Iron Treatment of Chlorinated Solvent DNAPL Source Areas				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) GeoSyntec Consultants, 26 Century Hill Drive, Suite 205, Latham, NY, 12110				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 80	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

CLEARANCE REQUEST FOR PUBLIC RELEASE OF DEPARTMENT OF DEFENSE INFORMATION

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1. DOCUMENT DESCRIPTION

a. TYPE Treatability Study	b. TITLE Emulsified Zero Valent Iron Treatment of Chlorinated Solvent DNAPL Source Areas (ER-0431)
c. PAGE COUNT 79	d. SUBJECT AREA Environmental Security Technology Certification Program

2. AUTHOR/SPEAKER

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3. PRESENTATION/PUBLICATION DATA (Date, Place, Event)

For posting on the ESTCP web site.

OPTIONAL FORM 99 (7-90)

To	From
Dept./Agency	Phone #
Fax #	Fax #
NSN 7540-01-217-7368 5069-101 GENERAL SERVICES ADMINISTRATION	

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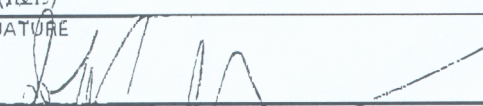
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c. NAME (Last, First, Middle Initial) Marqusee, Jeffrey	d. TITLE Director, ESTCP
e. OFFICE OUSD(I&F)	f. AGENCY OUSD (A&T)

g. SIGNATURE 	h. DATE SIGNED (YYYYMMDD) 20060601
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* 6 - 5 - 1742

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LIST OF ACRONYMS

cis-1,2-DCE	cis-1,2-Dichloroethene
Cl	chloride
CO ₂	carbon dioxide
<i>Dhc</i>	<i>Dehalococcoides</i>
DHGs	Dissolved hydrocarbon gases
DNAPL	dense nonaqueous phase liquid
DOC	dissolved organic carbon
DOD	Department of Defense
ESTCP	Environmental Security Technology Certification Program
EZVI	emulsified zero-valent iron
Fe	iron
GeoSyntec	GeoSyntec Consultants Inc.
GC	gas chromatograph
H	hydrogen
IC	ion chromatograph
L/h/m ²	liters per hour per square meter
mg/L	milligrams per liter
mmoles	millimoles
NASA	National Aeronautics & Space Administration
nZVI	nano-scale zero valent iron
PCR	polymerase chain reaction
PCE	tetrachloroethene
QL	quantitation limit
RPM	revolutions per minute
TCE	trichloroethene
VC	vinyl chloride
VOCs	volatile organic compound
VOA	volatile organic analysis
ZVI	zero-valent iron
µg/L	micrograms per liter

1 INTRODUCTION

This Laboratory Treatability Report has been prepared by GeoSyntec Consultants, Inc. (GeoSyntec) for the Environmental Security Technology Certification Program (ESTCP) review committee to present the results of the Pre-Design Laboratory Testing conducted as part of ESTCP project CU-0431. Laboratory experiments were conducted by SiREM Laboratories (a division of GeoSyntec) to determine the extent of DNAPL mass destruction by emulsified zero-valent iron (EZVI) that is due to abiotic and biological processes. GeoSyntec will review the results presented in this report with ESTCP and make a Go/No-Go decision regarding additional project tasks.

1.1 Background

Significant laboratory and field research has demonstrated that zero-valent metals will reductively dechlorinate dissolved chlorinated solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) to ethene in groundwater. Permeable reactive barriers (PRBs) containing zero-valent iron (ZVI) as the reactive material have been shown to be effective in treating plumes of dissolved chlorinated solvents. PRB technology is passive; however, it relies on dense non-aqueous phase liquid (DNAPL) dissolution and transport of dissolved chlorinated solvents to the PRB for treatment, and therefore PRBs do not reduce the clean-up time for sites where DNAPL is present. Nano-scale ZVI particles (nZVI), either in a water slurry or as particles contained within an oil emulsion droplet (EZVI), have advantages over the conventional PRB applications since they may be injected deeper in the subsurface than is practical for conventional PRBs, and can be injected directly into DNAPL source areas.

Additional background information on the nZVI and EZVI technologies is presented below (Sections 1.1.1 and 1.1.2 respectively).

1.1.1 Nano-Scale Zero-Valent Iron Technology Description

Laboratory and field tests have demonstrated that treatment of chlorinated ethenes such as TCE with nZVI particles is more rapid than with conventional forms of granular iron (Wang and Zhang, 1997; Lien and Zhang, 2001; Elliott and Zhang, 2001; Lowry et al. 2004). Nano-scale ZVI is significantly more reactive than micro-scale ZVI or iron powders because the smaller particle size gives the nZVI a larger surface area per unit mass. The degradation of chlorinated solvents by ZVI regardless of particle size is believed to occur via both reductive dechlorination and β -elimination (Arnold and Roberts, 2000). The dechlorination reactions occur at the iron surface and require excess electrons produced

from the corrosion of the ZVI in water. Through this process, the target chemicals undergo sequential dechlorination steps, resulting in the formation of non-chlorinated hydrocarbon products (e.g., ethene and ethane). The degradation of TCE may also occur via β -elimination where TCE is converted to chloroacetylene, which is further dechlorinated to acetylene. Acetylene is subsequently degraded to ethene and ethane.

As a result of their high reactivity, nano-scale particles containing ZVI are quickly surrounded by a passivating layer – such as a shell of oxide which limits the ZVI corrosion rate (Nurmi, et al. 2005). Zhang (2003) demonstrated that nZVI particles could remain reactive for 6 to 8 weeks in a water suspension in the laboratory. However, these highly reactive nano-scale particles change over time, with handling, during storage (in a slurry of water) and with exposure to natural environments where constituents in groundwater will decrease the reactivity of the particle surface.

Due to their very small size, nZVI particles may remain in suspension in groundwater and migrate downgradient of an injection point with the flow of groundwater (Elliott and Zhang, 2001). Some researchers (Schrack et al. 2004) have, however, questioned the mobility of nZVI in typical groundwater situations. The nZVI particles will agglomerate in many groundwater situations to form larger particles that are in the micron size range. Although it is possible to form stable suspensions of nano-scale particles (Schrack et al. 2004), aggregation of nano-scale particles may be difficult to avoid under most environmental conditions (Nurmi et al. 2005). This aggregation of the particles results in particle filtration by geological material preventing them from migrating with the flow of groundwater.

The nZVI particles require water for the degradation reactions to occur. Therefore, injecting the particles into a DNAPL source zone will still require the dissolution of the DNAPL into the surrounding water before degradation can occur. The rapid degradation of dissolved phase TCE by the fast-reacting nZVI may however enhance the dissolution of the DNAPL and reduce the clean up time for source zone DNAPL (Seagren et al. 1994).

Although the cost of nZVI varies depending on the volume ordered it is currently in the range of \$20 to \$28 per pound.

1.1.2 Emulsified Zero-Valent Iron Technology Description

EZVI can be used to enhance the destruction of chlorinated DNAPL in source zones by creating intimate contact between the DNAPL and the nZVI particles. The EZVI is composed of food-grade surfactant, biodegradable oil, water, and zero-valent iron particles (either nano- or micro-scale iron), which form emulsion particles. Each emulsion particle or droplet contains ZVI particles in water surrounded by an oil-liquid membrane. Since the

exterior oil membrane of the emulsion droplet has hydrophobic properties similar to that of DNAPL, the droplets are miscible with DNAPL. It is believed that as the oil emulsion droplets combine with DNAPL TCE, for example, the TCE is sequestered in the oil and then dissolves into the aqueous droplet containing nZVI that was within the oil emulsion droplet. It is also believed that the final degradation byproducts from the dechlorination reaction are driven by the increase in concentration inside the aqueous emulsion droplet to diffusion into the non-aqueous phase (oil and TCE) then out into the surrounding aqueous phase. While the nZVI in the aqueous emulsion droplet remains reactive, the chlorinated compounds are continually degraded within the aqueous emulsion droplets, thus maintaining a concentration gradient across the oil membrane and establishing a driving force for additional TCE migration into the aqueous emulsion droplet where additional degradation can occur.

The primary application of the EZVI technology is treatment of DNAPL source zones but it is also capable of treating dissolved-phase chemicals. EZVI that is located near DNAPL will also degrade the dissolved-phase chemicals that it comes in contact with. The reduction in concentration of dissolved-phase chemicals in the vicinity of the DNAPL will enhance mass dissolution from the DNAPL.

In addition to the abiotic degradation associated with the ZVI, the injection of EZVI containing vegetable oil and surfactant will result in sequestration of the chlorinated ethenes into the oil and biodegradation of dissolved chlorinated ethenes. Chlorinated solvents will preferentially dissolve into the oil component of the EZVI thereby reducing the aqueous phase concentrations. The chlorinated solvents may then be degraded by the ZVI in the EZVI. The vegetable oil and surfactant can also act as electron donors to promote anaerobic biodegradation of the chlorinated solvents. Abiotic degradation resulting from the ZVI in the EZVI was shown to be a very fast process in laboratory studies conducted at the University of Central Florida (UCF) (Quinn et al. 2005). If the amount of ZVI is not sufficient to completely degrade the TCE to ethene then the vegetable oil and surfactant can act as a slow release electron donor for biodegradation processes at the Site (Major et al. 2002).

Another potential benefit of EZVI over nZVI for environmental applications is that the hydrophobic membrane surrounding the nZVI protects it from other groundwater constituents, such as some inorganic compounds, that might otherwise react with the nZVI. While the oil membrane of the EZVI will allow organic constituents (TCE and other ethenes) to diffuse through the liquid membrane and contact the nZVI, it will inhibit diffusion of other ionic constituents and limit their contact with the nZVI. This mechanism potentially reduces the mass of nZVI required for treatment relative to unprotected nZVI.

The dominant cost of EZVI is the cost of the nZVI. Although the cost of nZVI and EZVI vary depending on the volume ordered it is currently in the range of \$20 to \$28 per

pound. Assuming a cost per pound for nZVI of \$24, the corresponding volume of EZVI, containing a pound of nZVI, would cost approximately \$28.

1.2 Objectives

The laboratory treatability study described in this report was designed to:

1. Determine an appropriate dechlorination assay for evaluating the reactivity of different batches and/or sources of nano-scale zero valent iron (nZVI).
2. Determine the extent of DNAPL mass destruction with EZVI that is due to abiotic and biological processes.

2 EXPERIMENTAL DESIGN

This section describes the experiments conducted as part of the work. Section 2.1 presents the general scope of the experiments conducted and Section 2.2 presents the approach and methods for experiments.

2.1 Scope of Treatability Experiments

The objectives were evaluated through three sets of experiments: 1) ZVI activity assays; 2) treatability tests conducted in bench-scale test reactors with dissolved phase TCE; and 3) treatability tests conducted in bench-scale test reactors with TCE DNAPL. ZVI activity assays were conducted to evaluate potential changes in the reactivity of the nZVI over time. Treatability tests were conducted to evaluate the ability of different components of the EZVI to treat dissolved and pure phase (DNAPL) TCE. Initial treatability tests were conducted using saturation concentrations of TCE (1,100 mg/L of TCE dissolved in water) with EZVI, nZVI and the oil emulsion components without nZVI. A set of tests was also conducted using TCE DNAPL (11,000 mg of TCE per liter of water in the reactor bottle, present as a separate non-aqueous phase) with EZVI, nZVI and the oil emulsion components without nZVI. All test treatments were constructed in triplicate sets of reactor bottles.

The treatability tests for dissolved phase TCE included: 1) sterile and intrinsic controls to evaluate abiotic losses due to sampling and incubation and biotic losses related to the water; 2) EZVI Treatments (sterile and active + KB-1TM) to evaluate abiotic and potential biologic degradation due to EZVI; 3) oil emulsion treatments (emulsion components without ZVI; active and sterile treatments with KB-1TM) to evaluate biologic degradation due to electron donors (oil and surfactant) and sequestration in the oil phase; and 4) nZVI Treatments (nZVI only; active and sterile treatments with KB-1TM) to evaluate abiotic degradation due to nZVI. Sterile test reactors were amended with mercuric chloride to inhibit microbial activity.

The results of the dissolved-phase treatment tests demonstrated very little difference in the results obtained with the active and sterile variations of the different treatment tests. As a result, all DNAPL treatments were active treatment (no mercuric chloride added). The treatability tests for DNAPL TCE were the same except that the sterile treatments were not included. Details of the construction, incubation and monitoring of the test reactors are presented in Section 2.2.

2.2 Approach and Methods

The following sections describe the: dechlorination activity assay tests (Section 2.2.1); dissolved phase TCE tests (Section 2.2.2); DNAPL TCE tests (Section 2.2.3); and test reactor sampling and analysis (Section 2.2.4).

2.2.1 Dechlorination Activity Assay Tests

Dechlorination activity assay tests were performed to evaluate the reactivity of different batches and/or sources of nano-scale zero-valent iron over time before the construction of the treatment test reactors. Nano-scale ZVI (product number: RNIP-10DS) from Toda Kogyo Co. in Japan, was received on 29 November 2004 and was used in the dechlorination assay tests and all test reactors containing nZVI and EZVI in this study.

All materials required to construct the dechlorination assays were placed in an anaerobic glove box. Dechlorination assays were constructed by filling 110 milliliter (mL) (nominal volume) glass bottles with 100 mL of anaerobic deionized water. The bottles were capped with Mininert™ closures to allow repetitive sampling with minimal volatile organic compound (VOC) loss.

All bottles were spiked with 1.91 mL of a saturated trichloroethene (TCE) solution (with an approximate concentration of 1,100 milligrams per liter [mg/L]) to achieve a target concentration of 20 mg/L. The bottles were held for 24 hours at room temperature to allow for the concentration of TCE in the water and headspace to equilibrate.

After the 24 hour equilibration period, a target nZVI concentration of 10 grams per liter (g/L) of dry nZVI was added to each of the bottles using the following procedure. A mass of 1.87 grams (g) of nZVI slurry (with a moisture content of 47%) was added to a weigh boat. The Mininert™ closure was removed and the nZVI was added to the dechlorination assay bottle by washing the nZVI into the bottle using a small amount (approximately 5 to 10 mL) of water from the bottle. The Mininert™ closure was replaced quickly after nZVI addition to prevent loss of VOCs. Following the addition of the nZVI the bottles were stored at room temperature on an orbital shaker set to shake at 150 rotations per minute (RPM). All dechlorination activity assay tests were constructed in duplicate.

2.2.2 Dissolved Phase TCE Tests

Initial tests were conducted using near saturation concentrations of TCE in the water. A total of twenty-seven test reactors (nine different treatments each in triplicate) were constructed on 14 December 2004. All materials required to construct the various test

reactors were placed in an anaerobic glove box. Test reactors were constructed in the glove box by filling 110 mL (nominal volume) glass bottles with 100 mL of anaerobic deionized water. The test reactors were capped with Mininert™ closures to allow repetitive sampling of the bottles with minimal VOC loss. All test reactors were spiked with 72 microliters (μL) of TCE to a target concentration of 1,100 mg/L (0.8 millimoles {mmol} of TCE per bottle). The amount of TCE and other chlorinated ethenes is presented in terms of mmoles per reactor bottle to allow comparison with the initial loading of TCE into the bottles on a molar basis. Test reactors were held for 24 hours to allow TCE concentrations in the water and headspace to equilibrate. Following this equilibration period, all test reactors were removed from the glove box and stored at room temperature on an orbital shaker rotating at 150 RPM. The amendments added to each of the nine different treatments are described below and are summarized in **Table 1**.

Sterile Control Treatment: Test reactors were amended with 1.85 mL of 2.7 percent (%) mercuric chloride (equal to a final liquid concentration of 0.05%) to inhibit microbial activity. The test reactors were then bioaugmented with KB-1™, an active bacterial culture known to degrade TCE to ethene under anaerobic conditions, to target concentration of 1×10^8 cells per liter (cells/L). This bacterial culture was added to determine if there were any components in the KB-1™ other than the active microorganisms that would effect the concentrations of the TCE during the test period.

Active Control Treatment: No amendments were added to these test reactors. This treatment was included to evaluate abiotic losses due to sampling and storage.

EZVI + KB-1™ Treatment: Test reactors were amended with 6.6 g of EZVI containing 0.636 g of nZVI on a dry weight basis dispensed from a 25 mL pipette into each test reactor. The amount of EZVI added to the EZVI treatment bottles was calculated based on five times the theoretical amount of nZVI required to degrade the TCE in the test reactor. The test reactors were then bioaugmented with KB-1™ to a target concentration of 1×10^8 cells/L.

Sterile EZVI + KB-1™ Treatment: Test reactors were amended with 1.85 mL of 2.7 percent (%) mercuric chloride (equal to a final liquid concentration of 0.05%) to inhibit microbial activity. The same quantities of EZVI and KB-1™ used in the “EZVI + KB-1™ Treatment” were then added to the test reactors.

Oil Emulsion + KB-1™ Treatment: Test reactors were amended with 6.0 mL of oil emulsion (vegetable oil, surfactant and water containing no nZVI) dispensed from a 25 mL pipette into each test reactor. The amount of oil emulsion added to this treatment was the same as was used in the EZVI treatment bottles. The test reactors were then bioaugmented with KB-1™ to a target concentration of 1×10^8 cells/L.

Sterile Oil Emulsion + KB-1TM Treatment: Test reactors were amended with 1.85 mL of 2.7% mercuric chloride (equal to a final liquid concentration of 0.05%) to inhibit microbial activity. The same quantities of oil emulsion and KB-1TM used in the “Oil Emulsion + KB-1TM Treatment” were then added to the test reactors.

ZVI + KB-1TM Treatment: A mass of 1.2 g of nZVI slurry (with a moisture content of 47%) was added to a weigh boat to provide a mass of 0.636 g of nZVI on a dry weight basis. The test reactors were opened and the nZVI was added to the reactor bottles by washing the nZVI into the bottle using a small amount (approximately 5 to 10 mL) of water from the bottles. The test reactors were then bioaugmented with KB-1TM to a target concentration of 1×10^8 cells/L.

Sterile ZVI + KB-1TM Treatment: Test reactors were amended with 1.85 mL of 2.7% mercuric chloride (equal to a final liquid concentration of 0.05%) to inhibit microbial activity. The same quantities of nZVI and KB-1TM used in the “ZVI + KB-1TM Treatment” were then added to the test reactors.

The deionized water used to construct the test reactors had a pH of approximately 6.5. Monitoring data collected during the initial six weeks showed that the pH of the bottles dropped below levels optimal for growth of the microorganisms in KB-1TM. There is no buffering capacity in the treatments as there is no soil in the test reactors. A possible source of the pH decrease could be from the partial dissolution and degradation of the vegetable oil releasing fatty acids in the treatments that had vegetable oil present (Emulsion and EZVI). It is also possible that in the EZVI treatments there is a diffusion limited transfer of the hydroxyl ions generated from the water in contact with the ZVI across the oil/water membrane. The pH of the biologically active treatments was buffered on day 54 and on day 62 and the treatments were re-amended with KB-1TM on day 62. The EZVI test reactors were respiked with an additional 0.8 mmoles of TCE on Day 134 and Day 184 to evaluate the capacity of the EZVI to treat additional TCE.

2.2.3 DNAPL Phase TCE Tests

A second set of treatability tests was conducted with greater than saturation concentrations of TCE added to the test reactors to form a DNAPL. A total of twelve test reactors (four different treatments each in triplicate) were constructed on 28 January 2005. All materials required to construct the various test reactors were placed in an anaerobic glove box. The DNAPL phase TCE treatments were constructed by adding 150 mL or 200 mL of anaerobic deionized water to 250 mL glass bottles. Smaller initial volumes of 150 mL of water were used for the EZVI and oil emulsion test reactors such that the liquid volume in the test reactors with the oil emulsion or EZVI added would be 200 mL. The test reactors were capped with MininertTM closures to allow repetitive sampling of the bottles

with minimal VOC loss. All test reactors were spiked with 1.5 mL of TCE for an initial loading of 16.7 mmol of TCE per 200 mL of liquid in the bottle, an amount equal to approximately ten times the saturation concentration of TCE in water. The test reactors were held for 72 hours to allow the TCE DNAPL to dissolve into the aqueous phase and reach equilibrium with headspace in the bottles.

Following this equilibration period, amendments were added to each of the four different treatments as described below and summarized in **Table 2**.

Active DNAPL Control Treatment: No amendments were made to these test reactors. This treatment was included to evaluate abiotic losses due to sampling and storage.

EZVI + KB-1TM DNAPL Treatment: Test reactors were amended with 56 g of EZVI containing 5.55 g of nZVI on a dry weight basis dispensed from a 25 mL pipette into each test reactor. The amount of EZVI added to the EZVI treatment bottles was calculated based on two times the theoretical amount of nZVI required to degrade the TCE in the test reactor. The test reactors were then bioaugmented with KB-1TM to a target concentration of 1×10^8 cells/L.

Oil Emulsion + KB-1TM DNAPL Treatment: Test reactor were amended with 50 mL of emulsion (vegetable oil, water and surfactant with no ZVI) dispensed from a 25 mL pipette into each test reactor. The amount of oil added to this treatment was the same as was used in the EZVI treatment bottles. The test reactors were then bioaugmented with KB-1TM to a target concentration of 1×10^8 cells/L.

ZVI + KB-1TM DNAPL Treatment: A mass of 10.47 g of nZVI slurry (with a moisture content of 47%) was added to a weigh boat. Test reactor closures were opened and the nZVI was added to each test reactor by washing the nZVI into the bottle using a small amount (approximately 5 to 10 mL) of water from the bottle. The test reactors were then bioaugmented with KB-1TM to a target concentration of 1×10^8 cells/L.

Test reactors were stored in the anaerobic glove box over the test period. Two of the replicates from the EZVI test reactors were respiked at 85 days with an additional 0.8 mmol of TCE to evaluate the capacity of the EZVI to treat additional TCE. Sampling and analysis conducted during the test period is described in Section 2.2.4.

2.2.4 Test Reactor Sampling and Analysis

Water samples were collected from the treatment test reactors on a regular basis and analyzed for chlorinated ethenes, dissolved hydrocarbon gases (DHGs) (ethene, and ethane) and chloride and lactate. Test reactors and activity assays were sampled using gas-tight 10 μ L, 100 μ L, and 1 mL Hamilton glass syringes. Syringes were cleaned with acidified water

(~pH 2) and rinsed 10 times with deionized water between samples, to ensure that VOCs and microorganisms were not transferred between different samples or treatments. Analysis of samples was conducted by GeoSyntec's SiREM Lab division using the analytical methods described below.

Analysis of Chlorinated Ethenes and Dissolved Hydrocarbon Gases

This section describes the methods used to quantify the chlorinated ethenes, and DHGs.

Aqueous chlorinated ethenes and DHG concentrations in the test reactors and activity assays were measured using a Hewlett-Packard (Hewlett Packard 5890 series II Plus) gas chromatograph (GC) equipped with a head-space auto sampler (Hewlett Packard 7684) programmed to heat each sample to 75 degrees Celsius (°C) for 45 minutes prior to injection into a GSQ Plot column (0.53 millimeters x 30 meters, J&W) and a flame ionization detector. The injector temperature was 200°C, and the detector temperature was 250°C. The oven temperature was programmed as follows: 35°C for 2 min, increase to 100°C at 50 degrees Celsius per minute [°C/min], then increase to 185°C at 25°C/min and hold at 185°C for 5.80 min. The carrier gas was helium at a flow rate of 11 milliliters per minute (mL/min).

After collecting water samples from the test reactor bottles the samples were injected into a 10 mL headspace vial containing 5.0 mL of acidified deionized water. The vial was sealed with an inert Teflon™ coated septum and aluminum crimp cap for automated injection onto the GC. A five-point calibration was performed using methanolic stock solutions containing known concentrations of the target analytes. Calibration was performed using external standards that were prepared gravimetrically, or were purchased as standard solutions. Data were integrated using Peak Simple Chromatography Data System Software (SRI, Inc.)

The total quantities of chlorinated ethenes, ethene and ethane in the reactor bottles were calculated at the time of each sampling event using the aqueous phase concentrations of each compound to estimate the quantity of each compound in the headspace of the bottles in equilibrium with the aqueous phase concentration based on Henry's Law and adding this quantity to the amount measured in the aqueous phase. The quantity of each compound reported does not include the quantity contained in any non-aqueous phase (in an oil phase or adsorbed onto a solid matrix) in the bottles.

Analysis of Chloride and Lactate

This section describes the methods to quantify chloride and lactate. The quantitation limits (QLs) for chloride and lactate were 0.03 and 0.25 mg/L respectively.

During sampling, 0.5 mL samples of water were collected from the bottles and the samples were placed in 1.5 mL micro-centrifuge tubes. Samples were centrifuged for five minutes to settle out solids. The supernatant was removed, diluted 10-fold in deionized water and placed in a Dionex auto-sampler vial with a filter cap for automated injection onto the ion chromatograph (IC).

Analysis was performed on a Dionex DX-600 IC equipped with a Dionex AS-40 auto-sampler and an AS18 column. The sample loop volume was 25 μ L. An isocratic separation was performed using 33 millimolar (mM) sodium hydroxide eluent for 13 minutes. Calibration was performed using external standards of known concentrations. Data were integrated using Dionex's Peaknet chromatography software. The lactate value included any other volatile fatty acids, such as acetate and propionate, as the analytical method does not resolve these compounds.

The values reported in this report are quantities contained in the aqueous phase only and does not account for mass that may be contained in any non-aqueous phase in the bottles.

3 RESULTS AND DISCUSSION

This section presents the results of laboratory tests conducted to evaluate the activity of the nZVI prior to the degradation treatability tests (Section 3.1) and to evaluate the degradation of dissolved phase TCE (Section 3.2) and DNAPL TCE (Section 3.3) in the presence of EZVI and the components of EZVI.

3.1 Activity Assays

Figure 1 presents graphs of the molar quantities (in millimoles per bottle) of chlorinated ethenes, ethene and ethane concentrations measured during the activity assays conducted prior to the dissolved phase and DNAPL phase treatment tests. **Table 3a** and **3b** provide VOC data for the activity assays. The activity assays were conducted using water with 20 mg/L of TCE and 10 g/L of nZVI on a dry weight basis from the same batch of Toda Kogyo iron. In the activity assay conducted just prior to the dissolved phase treatments, TCE was not detected in samples collected from the assay bottles after Day 5 of the test. In the activity assay conducted just prior to the DNAPL phase treatments TCE was detected at Day 5 but not detected on Day 7 of the test.

The rate of dechlorination in a batch reactor can be described by the following equation (Johnson, et al. 1996):

$$dC/dt = -k_{SA} \cdot a_s \cdot \rho_m \cdot C$$

where C = the concentration of the organic contaminant in the aqueous phase (mg/L), k_{SA} = the surface area normalized rate coefficient (L/h/m²), a_s = the specific surface area of the iron particles (m²/g) and ρ_m = the mass concentration of iron in the bottle (g/L). For a specific system, k_{SA} , a_s , and ρ_m are constants, and $k_{OBS} = k_{SA} \cdot \rho_m \cdot a_s$, where k_{OBS} = pseudo first-order rate coefficient (hr⁻¹).

A pseudo-first-order rate coefficient was calculated for each activity assay based on the linear regression of the TCE data from the activity assays. The pseudo first-order rate coefficient was then used to determine a surface-area-normalized rate coefficient. The values used in the equations their sources are presented in the table below.

Input Parameters	Dissolved Phase Test	DNAPL Phase Test	Source
Mass concentration of metal - ρ_m (g/L)	10	10	Experiment dependent
Specific surface area - a_s (m ² /g)	23	23	Lowry, et al. 2004
Pseudo-first-order rate coefficient - k_{OBS} (hr ⁻¹)	0.0499	0.0266	Linear regression of results
Surface-area-normalized rate coefficient - k_{SA} (L/h/m ²)	0.00022	0.00012	Calculated

The data from the activity assays conducted before the dissolved phase tests and before the DNAPL phase tests demonstrate that the nZVI lost some of its reactivity in the two months between the two tests. The surface-area-normalized rate coefficient for the first activity assay was 0.00022 liters per hour per square meter (L/h/m²) and it decreased to 0.00012 L/h/m² in the next test. This decrease in reactivity must be considered in the evaluation of the data from the treatability tests and the potential for loss of reactivity must be considered during field-scale applications of the technology. The data highlight the need to minimize the storage time for nZVI before applying the technology in the field.

3.2 Results from Dissolved Phase Test Reactors

Figure 2 presents graphs of the molar quantities (in millimoles per bottle) of chlorinated ethenes, ethene and ethane during treatment in each of the test reactors constructed using the near saturation dissolved-phase concentrations of TCE. **Table 4** provides the anion, pH and DOC data for the dissolved phase test reactors. The chloride concentration data in **Table 4** and in **Figure 3** can be used to confirm that the decrease in TCE concentrations is due to the degradation of the chlorinated compounds and not to other losses. Chloride concentrations will increase as TCE is degraded. **Tables 5 to 12** provide chlorinated ethene data from the control and treatment test reactors over the period of the study. All chlorinated ethene and DHG quantities are presented in units of mg/L and millimoles per microcosm bottle (mmol/bottle) to demonstrate mass balances on a molar basis. As discussed in Section 2.2.4 the quantities of chlorinated ethenes include the quantity in the aqueous phase plus an estimate of the quantity in the headspace of the reactor

bottles. The quantity of each compound reported does not include the quantity contained in any non-aqueous phase in the bottles.

3.2.1 Results of Individual Treatments

Figure 2a shows the results of the Active Control treatment over the duration of the test. The results obtained with the Sterile and Active Control treatments (shown in **Tables 5 and 6**) were virtually identical and only the data from the Active Control treatment are shown in **Figure 2**. No degradation of the TCE was observed in the controls and there were no significant losses of VOCs due to sampling and incubation of the test reactors. The chloride concentration, which would be expected to increase if TCE is degraded, remained unchanged over the duration of the experiment in both the Active and Sterile Controls (**Table 4 and Figure 3**). The concentration of chloride in the Sterile Control is higher (average of 130 mg/L) than the Active Control (5.4 mg/L) due to the addition of 1.85 mL of 2.7 % mercuric chloride (equal to a final liquid concentration of 0.05%) to inhibit microbial activity.

Figures 2b and 2c show the results of the dissolved-phase TCE Oil Emulsion treatments. **Tables 7 and 8** contain the chlorinated ethene and DHG data for the Oil Emulsion and Sterile Oil Emulsion treatments. In the Oil Emulsion treatments, the TCE in the reactor bottles dropped almost immediately from 0.8 mmol to approximately 0.15 mmol. During the first 50 days of treatment no by-products were observed, indicating that the decreases in the quantity of TCE is likely due to the sequestration of the TCE into the vegetable oil. The unchanging chloride concentrations in the first 50 days (**Table 4 and Figure 3**) also indicate that the reduction in TCE is due to sequestration of the TCE into the oil phase and not degradation. After the pH was buffered and the test reactors were re-amended with KB-1TM at Day 62, the TCE started to increase in the active (i.e., not sterilized) Oil Emulsion treatment (**Figure 2c**) and some TCE was degraded to cis-1,2-dichloroethene (cDCE). The increase in TCE may have been due to bacteria breaking down the vegetable oil and releasing some of the sequestered TCE into the water. Although there was some conversion of the TCE to cDCE, KB-1TM does not appear to have been able to degrade the TCE to ethene. This may have been a result of the use of deionized water to construct the test reactors rather than natural groundwater. Micronutrients and additional microorganisms that may assist in breaking down the vegetable oil into electron donor usable by the *Dhc* exist in natural groundwater and their absence in the test reactors may have limited the effectiveness of biodegradation processes.

Figures 2d and 2e and Tables 9 and 10 show the chlorinated ethene and DHG results of the nZVI treatments. There were no significant differences between the sterile and active nZVI treatments, indicating that the dominant degradation mechanism in these test reactors

was abiotic degradation associated with the nZVI. The quantity of TCE dropped rapidly down to 0.17 mmol per bottle within the first day.

After the first 7 days, very low quantities of TCE persisted in the nZVI treatment test reactors. The concentrations of TCE decreased from an average of 0.009 mmol to 0.001 mmol on Day 63, until Day 69 when TCE was non-detect. Trace amounts of cDCE and vinyl chloride (VC) were detected in the samples but the data show that most of the TCE was converted to non-chlorinated end-products such as ethene and ethane. Due to analytical constraints, the only gases that were analyzed were ethene and ethane although it is expected that other C2 and C4 gases are being produced (e.g., acetylene, butane, 1-butylene) and may account for the decrease in total ethenes and ethane (Liu et al. 2005).

The decrease in TCE in the nZVI treatment was accompanied by a rapid increase in the chloride concentrations from approximately 2 mg/L to 942 mg/L by Day 8 in the active nZVI treatment (**Figure 3**). The chloride concentrations varied between 722 mg/L and just over 900 mg/L for the remainder of the test. The TCE added to the reactors (0.8 mmoles) could produce 85 mg of chloride if it was completely degraded (0.8 mmoles of TCE times 106.35 mg of chlorine per mmoles of TCE). The 85 mg in the 100 ml bottles would be expected to produce an aqueous phase concentration of 850 mg/L of chloride in the bottles. The measured concentrations of chloride between 722 and 942 mg/L demonstration there was virtually complete degradation of the TCE in the ZVI treatment. The chloride concentrations in the Sterile ZVI treatment (**Table 4**) are slightly higher than in the Active ZVI treatment due to the addition of mercuric chloride to inhibit microbial activity.

Figures 2f and 2g and Tables 11 and 12 show the chlorinated ethene and DHG results of the EZVI treatments. The results obtained with both the sterile and active EZVI treatments were very similar indicating that the decreases in the quantities of TCE observed were due to the ZVI and sequestration into the oil emulsion and not due to biological activity. In these treatments, the quantity of TCE dropped almost immediately from 0.8 mmol down to 0.06 mmol. This initial drop is likely due to a combination of the sequestration of the TCE into the vegetable oil and the degradation of the TCE by the ZVI. Other than small quantities of cDCE and trace amounts of VC, the main degradation products observed in the EZVI treatments were ethene and ethane. At Day 57 two of the EZVI test reactors were sacrificed to determine the quantities of VOCs partitioned into the oil phase of the emulsion droplets. The oil phase from these test reactors contained an average of 0.0128 mmol chlorinated ethenes (0.0034 mmol of TCE and 0.0094 mmol of cDCE). The initial loading of TCE to each of the reactors was 0.8 mmol and 0.01 mmol of chlorinated ethenes were present in the water when the oil phase samples were taken. This data suggests that 98% of the TCE initially added to the bottles was converted to non-chlorinated end products in the EZVI treatments. By Day 77, TCE was non-detected in the water in both the sterile and active test reactors.

As with the ZVI treatment, the decrease in TCE was accompanied by an increase in the chloride concentrations in the aqueous phase; however, in the EZVI treatments the increase in chloride concentrations took place gradually over the experiment (**Figure 3**). The final chloride concentration at 113 days was 809 mg/L. As discussed earlier, the TCE added to the reactors would be expected to produce a concentration of 850 mg/L of chloride in the aqueous phase. The chloride concentration in the EZVI test increased slowly and was likely still increasing when it reached 809 mg/L at 113 days. These data show that the TCE in the EZVI treatment is degraded and not just sequestered in the oil. The slow increase in chloride may be due to slow degradation of the TCE or slow diffusion of the chloride out of the emulsion following dechlorination of the TCE. The measured concentration of chloride of 809 mg/L at day 113 demonstrates there was degradation of at least 95% of the TCE in the EZVI treatment. This may be an underestimate of the amount of degradation if there was residual chloride still in the emulsion at the time the sample was collected that is not measured in the aqueous phase sample.

All three replicates of the EZVI + KB-1TM dissolved phase treatment were respiked with 0.8 mmol of TCE on Day 134 and again on Day 183. The results of EZVI + KB-1TM treatments are contained in **Table 11** and shown graphically on **Figure 2f**. On Day 108, the last set of samples collected before respiking with TCE, the TCE quantities in the treatment bottles were non-detect, the cDCE was 0.002 mmol, the ethene was 0.10 mmol and the ethane was 0.023 mmol. When the bottles were respiked with 0.8 mmol of TCE the TCE measured immediately after respiking was 0.098 mmol. This indicated that most of the additional TCE was rapidly sequestered into the oil phase of the EZVI. The bottles were respiked with an additional 0.8 mmol of TCE on Day 183. Although the TCE immediately dropped to 0.098 mmol, the ethene and ethane did not change significantly indicating that the decreases in TCE were likely due to the TCE being sequestered into the oil phase of the EZVI. It appears that the EZVI had sufficient capacity to sequester additional TCE into the oil.

3.2.2 Comparison of Different Treatments

All three treatment types: oil emulsion, ZVI and EZVI showed significant and rapid decreases in TCE relative to the active control (**Figure 2**). The decrease in TCE in the oil emulsion treatment is believed to be due sequestration of the TCE into the oil as there was little production of chloride observed. The decrease in the quantity of TCE in the nZVI treatment was accompanied by an increase in the aqueous phase concentration of chloride demonstrating that complete degradation of the TCE was achieved in a very short period of time. The results were virtually identical for the active and the sterile nZVI treatments demonstrating that the degradation is due to abiotic degradation of the TCE resulting from the nZVI. The rapid decrease in TCE in the EZVI treatment is believed to be due to a

combination of both sequestration and abiotic degradation. The decrease in the quantity of TCE in the EZVI treatment was followed by a slow increase in the aqueous phase concentration of chloride demonstrating that complete degradation of the initial spike of TCE was eventually achieved.

3.3 Results from DNAPL Test Reactors

Figure 4 shows the quantity of chlorinated ethenes, ethene and ethane during treatment in each of the test reactors constructed using TCE DNAPL. The data in this Figure are shown in mmols per bottle to allow a comparison with the amount of TCE added originally to the test reactors (16.7 mmols per bottle) and to allow a comparison of molar quantities of the different compounds. **Table 13** provides the chloride, pH and DOC data for the DNAPL phase test reactors. **Figure 5** shows the aqueous concentrations of chloride in the control and different treatment during the test. As discussed previously in Section 3.2, chloride concentration data can be used to confirm the decrease in TCE concentrations is due to the degradation of the chlorinated compounds and not to other losses. **Tables 14 to 17** provide VOC data from the control and treatment test reactors over the period of the study.

3.3.1 Results of Individual Treatments

Figure 4a shows the chlorinated ethene and DHG results of the Intrinsic Control treatment. As expected, no degradation of the TCE occurred in the controls and there were no significant losses due to sampling and incubation of the test reactors. The chloride concentration remains unchanged for the duration of the test (**Table 13** and **Figure 5**) confirming that there is no degradation of chlorinated compounds occurring.

In the Oil Emulsion treatments (without ZVI; **Figure 4b**, **Table 15**), the quantity of TCE dropped almost immediately to approximately 0.5 mmol. This immediate drop in VOC concentrations is believed to be due to the sequestration of the DNAPL into the oily phase of the emulsion since the chloride concentration remains relatively unchanged for the duration of the test (**Table 13** and **Figure 5**). Although there is some variability in the TCE concentrations measured in the water phase, no degradation products were observed. Between Day 3 and Day 27 the quantity of TCE remained at about 0.5 mmol per bottle and there were no degradation products observed. The oil emulsion contains oil, water and surfactant and is therefore a light non-aqueous phase liquid (LNAPL) that floats on the top of the water. As the TCE DNAPL combined with the oil emulsion, a portion of the emulsion became denser than water and settled to the bottom of the bottle as a DNAPL. On Day 27 a separate DNAPL phase could still be observed in the vial.

Figure 4c and **Table 15** show the results of the ZVI treatments. The amount of TCE measured in the water in the reactor bottles throughout the duration of the test ranged between 1.2 and 2.0 mmol per bottle, close to the saturation concentration of TCE of 1.67 mmol per bottle. The amount of TCE measured in the aqueous phase in the bottles corresponds to the amount that would be expected to be observed in water in the presence of TCE DNAPL. There was an increase in the amount of ethane at the start of the test (up to 4 mmol per bottle) and small amounts of ethene and cDCE. The gradual decline in the total ethenes and ethane is likely due to the natural degradation of non-chlorinated ethane and ethene or due to losses of these volatile gasses during sampling.

In the ZVI treatments, there was an increase in the aqueous chloride concentration from 68 mg/L at time 0; 1,970 mg/L at Day 8; 2,650 mg/L at Day 64; and 5,800 mg/L at Day 188 (**Figure 5** and **Table 13**). The TCE added to the reactors (16.7 mmol) could produce 1,776 mg of chloride if it was completely degraded (16.7 mmol of TCE times 106.35 mg of chlorine per mmol of TCE). The 1,776 mg in the 200 ml of water in the bottles would produce an aqueous phase concentration of 8,880 mg/L of chloride. The measured aqueous phase concentrations of chloride up to 5,800 mg/L demonstrate there was degradation of approximately 65% of the TCE at Day 188 in the ZVI treatment. The TCE concentration in the ZVI bottles was stable at about the saturation concentration from about 3 days up to the last sampling event for chlorinated ethenes at Day 63. During the test, a dense material believed to contain residual iron particles and TCE DNAPL was present in the bottom of the bottles. The data and observations suggest that the nZVI alone was capable of degrading at least 65% of the original mass of TCE DNAPL but that the aqueous concentration of TCE remained at saturation concentrations because of the presence of some residual TCE DNAPL.

Figure 4d and **Table 17** shows the chlorinated ethene and DHG results for the EZVI DNAPL phase treatments. In the EZVI treatments the amount of nZVI in the EZVI added to the test reactors was exactly the same as that added to the ZVI treatments. In the EZVI treatment, the quantity of TCE in the non-oil phase decreased almost immediately down to 0.18 mmol by the end of the first day. The quantity of TCE after day one was much lower in the EZVI treatments than in the ZVI due to the additional benefit of the sequestration of the TCE into the oil phase. As in the ZVI treatments, there was an initial increase in ethane but it quickly switched to ethene production. Very low quantities of cDCE were measured and no VC was observed. In the EZVI treatments, there was little increase in the chloride concentration from the start of the test to Day 64 (**Figure 5** and **Table 13**).

At Day 85 an additional 0.8 mmol of TCE was added to the test reactors. There were no significant changes in the measured quantities of chlorinated ethene or DHGs in the non-oil phases of the test reactors (**Figure 4d**) suggesting that the additional TCE was quickly sequestered into the oil phase.

At Day 157 two of the EZVI test reactors were sacrificed to determine the quantity of chlorinated ethenes partitioned into the oil phase of the emulsion droplets. The oil phase from these test reactors was found to have an average of 2.94 mmol chlorinated ethenes (2.68 mmol of TCE and 0.26 mmol of cDCE). The initial loading of TCE to each of the reactors was 16.7 mmol and an additional 0.8 mmoles was added at Day 85 for a total of 17.5 mmoles. Based on sampling of the aqueous phase in the test reactors on Day 157, 0.173 mmol of chlorinated ethenes were present in the water when the oil phase samples were taken. This data suggests that 82% of the TCE added to the bottles was converted to non-chlorinated end products in the EZVI treatments by Day 157 of the test.

In the EZVI treatments, there was little increase in the chloride concentration from the start of the test to Day 64 (**Figure 5** and **Table 13**). The concentration; however, increased significantly to 5,727 mg/L after 174 days. As discussed earlier, the TCE added to the reactors initially could produce a concentration of 8,880 mg/L of chloride in the water in the sample bottles. The EZVI treatment bottles were re-spiked with TCE after 85 days such that the concentration of chloride would be 9,305 mg/L if all the TCE were to be degraded. The measured concentration of chloride in the water of 5,727 mg/L demonstrates there was degradation of at least 61.5% of the TCE at Day 174 in the ZVI treatment. As discussed earlier, analysis of the oil and water at 157 days showed that 82% of the TCE was degraded. Analysis was not performed to determine the amount of chloride present in the oil phase in the reactor bottles. It is believed that a significant proportion of the missing chloride mass may have been present as inorganic chloride in the EZVI.

3.3.2 Comparison of Different Treatments

The three different treatments (oil emulsion, nZVI and EZVI) showed substantially different performance treating TCE DNAPL. As in the dissolved-phase treatments, the Oil Emulsion treatment quickly reduced the aqueous phase concentration of TCE to less than the solubility of TCE in water but a residual concentration of 200 to 400 mg/L of TCE remained in the aqueous phase for the duration of the test. These results are believed to be primarily due to sequestering the TCE into the oil phase as no degradation products were measured in these reactors. In the ZVI treatments, the concentration of the TCE dropped to near the saturation concentration of about 1,100 mg/L within the first day but no further decrease in TCE concentrations were observed after 55 days. The production of ethane, ethene and chloride indicate that significant degradation of the TCE was occurring as a result of the nZVI but this degradation did not result in a decrease the aqueous phase concentrations below the saturation concentration during the test. The EZVI treatments showed the most promising results with concentrations of TCE decreasing within a few hours to about 300 mg/L (30% of the saturation concentration of TCE) then decreasing to about 100 mg/L (10% of the saturation concentration) within about a week. The production of ethene and eventual production of chloride indicates that the TCE is being degraded by the nZVI in the EZVI.

This treatment benefits from both the sequestration of the TCE by the oil phase and degradation due to the nZVI.

The DNAPL Treatment tests demonstrate the advantages of EZVI over straight vegetable oil addition or nZVI in situation where a DNAPL is present in the subsurface. The EZVI combines the sequestration of the DNAPL with the degradation of the VOCs by the nZVI resulting in an immediate reduction in the TCE flux from the source area as well as degradation due to the nZVI. As with the dissolved-phase treatment the EZVI provides the complete degradation of the TCE to ethene in a similar time frame as the nZVI and also provides sequestration of any potential untreated VOCs and the addition of an electron donor for follow-on biodegradation of any potential untreated chlorinated ethenes for field applications where the source area may require enhancements to natural biological processes. .

4 CONCLUSIONS

This section presents the major conclusion drawn from the results of laboratory test conducted to evaluate the degradation of TCE in the presence of EZVI and the components of EZVI. The following conclusions have been made based on the results of the laboratory tests presented in this Laboratory Treatability Report:

1. Oil emulsion, nZVI and EZVI treatment of dissolved phase TCE can produce significant and rapid decreases in TCE concentrations in the aqueous phase. The data for the lab tests suggest that the decrease in TCE in the oil emulsion treatment is due sequestration of the TCE into the oil; in the nZVI treatment is due to abiotic degradation of the TCE associated with the nZVI; and in the EZVI treatment is due to a combination of both sequestration and abiotic degradation. Biological degradation of dissolved phase TCE in the test conditions was not significant in any of the different treatments.
2. Oil emulsion treatment of TCE DNAPL can reduce aqueous phase concentration of TCE to less than the solubility of TCE in water but a significant residual concentration of TCE (e.g., 200 to 400 mg/L versus a solubility of 1,100 mg/L) can remained in the aqueous phase. The data for the lab tests suggest that the decrease in TCE is due to sequestering the TCE into the oil phase and that the residual TCE in the aqueous phase is a result of the very high loading of TCE into the oil in the presence of DNAPL.
3. nZVI treatment of TCE DNAPL was not able to reduce aqueous concentrations below the saturation concentration of about 1,100 mg/L. The production of ethane, ethene and chloride indicates that significant degradation of the TCE was occurring as a result of the nZVI but this degradation did not result in a decrease the aqueous phase concentrations below the saturation concentration during the 55 day test. The concentration of chloride measured in the aqueous phase after 188 days demonstrated that 65% of the original mass of TCE DNAPL was degraded.
4. EZVI treatment of TCE DNAPL was able to reduce concentrations of TCE to about 100 mg/L (10% of the saturation concentration) within a week after treatment. The production of ethene and eventual production of chloride indicates that the TCE is being degraded by the nZVI in the EZVI. The reduction in TCE is believed to be from both the sequestration of the TCE by the oil phase and degradation due to the nZVI. Analysis of the oil phase and water phase suggest that 82% of the original TCE DNAPL added to the treatment bottle was degraded at Day 157. The concentration of chloride measured in the aqueous phase after 188 days demonstrated that at least 61.5% of the original mass of TCE DNAPL was degraded. The discrepancy between the estimate of the percent of mass degraded from

chlorinated ethene and chloride analysis may be a result of additional chloride trapped in the EZVI which was not detected in the aqueous phase analysis.

5. The DNAPL Treatment tests demonstrate the advantages of EZVI over oil emulsions or nZVI in situation where a DNAPL is present in the subsurface. The EZVI combines the sequestration of the DNAPL with the degradation of the VOCs by the nZVI resulting in an immediate reduction in the TCE flux from the source area as well as degradation due to the nZVI. The EZVI provides degradation of the TCE to ethene in a similar time frame as the nZVI and also provides sequestration of any potential untreated VOCs.
6. The EZVI provides oil that should be able to act as an electron donor to promote biodegradation of TCE which is not degraded by the nZVI. The potential beneficial effects of this biodegradation were not observed to a significant degree in the laboratory tests conducted to date, likely because site groundwater and soil were not used in the test reactors.

5 REFERENCES

- Arnold, W. A., A.L. Roberts. 2000. Pathways and Kinetics of Chlorinated Ethylene and Chlorinated Acetylene Reaction with Fe(0) particles. *Environ. Sci. Technol.* 2000, vol 34 pp 1794-1805. 2000.
- Elliott, D.W., and W.-X. Zhang. 2001. Field Assessment of Nanoscale Bimetallic Particles for Groundwater Treatment. *Environ. Sci. Technol.* 2001, vol 35, No. 24, pp 4922-4926. 2001.
- Geiger, C. L., C. A. Clausen, D. R. Reinhart, J. Quinn, T. Krug, and D. Major. "Nanoscale and Microscale Iron Emulsions for Treating DNAPL." *Chlorinated solvent and DNAPL remediation: innovative strategies for subsurface cleanup. ACS Symposium Series, Vol. 837*. Edited by Susan M. Henry and Scott D. Warner. ACS, 2003. Chem. 660.8 A512A v. 837
- Johnson, T.L., M.M. Scherer, and P.G. Tratnyek. 1996. Kinetics of Halogenated Organic Compound Degradation by Iron Metal. *Environ. Sci. Technol.* 1996, vol 30, pp 2634-2640. 1996.
- Lien, H. and W. Zhang. 1999. Transformation of Chlorinated Methanes by Nanoscale Iron Particles. *J. Environ. Eng.* Vol 125, pp. 1042-1047. 1999.
- Liu, Y., S. A. Majetich, R.D. Tilton, D.S. Sholl, and G.V. Lowry. 2005. TCE Dechlorination Rates, Pathways, and Efficiency of Nanoscale Iron Particles with Different Properties. *Environ. Sci. Technol.* 2005, vol 39, No. 5, pp 1338-1345. March 2005.
- Lowry, G.V., Johnson, K.M. 2004. Congener-specific Dechlorination of Dissolved PCBs by Microscale and Nanoscale Zerovalent Iron in a Water/Methanol Solution. *Environ. Sci. Technol.* 2004, vol 38, pp 5208-5216. 2004.
- Major, D., M. McMaster, E. Cox, E. Edwards, S. Dworatzek, E. Hendrickson, M. Starr, and L. Buonamici. 2002. Field Demonstration of Successful Bioaugmentation to Achieve Dechlorination of Tetrachloroethene to ethene. *Environ. Sci. Technol.* 2002, vol 36 (23), pp 5106-5116. 2002
- Nurmi, J.T, P. G. Tratnyek, V. Sarathy, D. R. Baer, J. E. A Monette, K. Pecher, C. Wang, J. C. Linehan, D. W. Matson, R. L. Renn, and M. D. Driessen. 2005. Characterization And Properties Of Metallic Iron Nanoparticles: Spectroscopy, Electrochemistry, and Kinetics. *Environ. Sci. Technol.* 2005, vol 39, No. 5, pp 1221-1230. March 2005.

Quinn, J., C. Geiger, C. Clausen, K. Brooks, C. Coon, S. O'Hara, T. Krug, D. Major, W.-S. Yoon, A. Gavaskar, and T. Holdsworth. 2005. Field Demonstration of DNAPL Dehalogenation Using Emulsified Zero-Valent Iron. *Environ. Sci. Technol.* 2005, vol 39, No. 5, pp 1309-1318. March 2005.

Schirck, B., B.W. Hydutsky, J.L. Blough, and T.E. Mallouk. 2004. Delivery Vehicles for Zerovalent Metal Nanoparticles in Soil and Groundwater. *Chem. Mater.* Vol 16., pp. 2187-2193. 2004.

Seagren, E.A., B.E. Rittman, and A.J. Valocchi, 1993. Quantitative Evaluation Of Flushing And Biodegradation For Enhancing In Situ Dissolution Of Non-Aqueous Phase Liquids, *Journal of Contaminant Hydrology*, 12:103-132. 1993.

Wang, C., and W. Zhang. 1997. Synthesizing Nanoscale Iron Particles For Rapid and Complete Dechlorination of TCE and PCBs. *Environ. Sci. Technol.* 1997, Vol. 31 pp. 2154-2156.

Zhang, W., 2003. Nanoscale Iron Particles for Environmental Remediation. *J. Nanopart. Res.* , 5, 323-332. 2003.

TABLE 1: Summary of Dissolved Phase Controls and Treatments
EZVI Laboratory Treatability Study

Treatment Components					
Test Reactors	Anaerobic water Spiked with TCE	Mercuric chloride	KB-1™	ZVI	Oil and Surfactant
Sterile Control	x	x	x		
Active Control	x				
EZVI + KB-1™	x		x	x	x
Sterile EZVI + KB-1™	x	x	x	x	x
Oil Emulsion + KB-1™	x		x		x
Sterile Oil Emulsion + KB-1™	x	x	x		x
ZVI + KB-1™	x		x	x	
Sterile ZVI + KB-1™	x	x	x	x	

TABLE 2: Summary of DNAPL Phase Controls and Treatments
EZVI Laboratory Treatability Study

Treatment Components					
Test Reactors	Anaerobic water Spiked with TCE	Mercuric chloride	KB-1™	ZVI	Oil and Surfactant
Active Control	x				
EZVI + KB-1™	x				
Oil Emulsion + KB-1™	x		x	x	x
ZVI + KB-1™	x			x	x

TABLE 3a: SUMMARY OF ACTIVITY ASSAY TESTS CONDUCTED FOR DISSOLVED PHASE TREATMENT TEST
EZVI Laboratory Treatability Study

SiREM

TREATMENT	DATE	day	REPLICATE	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/L
20 mg/L TCE with 10 g/L nZVI	01-Dec-04	0.04	2	18	0.022	<0.02	0.02	<0.02	
			3	16	0.021	<0.02	0.02	<0.02	
			4	16	<0.02	<0.02	0.04	<0.02	
			Average Conc. (mg/L)	17	0.014	0.0	0.0	0.0	
			Standard Deviation (mg/L)	8.3E-01	1.2E-02	0.0E+00	1.2E-02	0.0E+00	
			Average Amount (mmol)	0.0135	1.53E-05	0.0	1.76E-04	0.0	0.0137
	01-Dec-04	0.08	2	15	0.02	<0.02	0.06	0.072	
			3	16	0.02	<0.02	0.05	0.075	
			4	16	0.02	<0.02	0.06	0.090	
			Average Conc. (mg/L)	16	0.02	0.00	0.06	0.08	
			Standard Deviation (mg/L)	3.7E-01	1.3E-03	0.0E+00	5.1E-03	9.5E-03	
			Average Amount (mmol)	0.0124	1.77E-05	0.0	3.86E-04	7.83E-04	0.0128
	01-Dec-04	0.25	2	12	0.052	<0.02	0.14	0.20	
			3	13	0.044	<0.02	0.13	0.18	
			4	12	0.067	<0.02	0.19	0.28	
			Average Conc. (mg/L)	12	0.05	0.00	0.16	0.22	
			Standard Deviation (mg/L)	8.5E-01	1.1E-02	0.0E+00	3.4E-02	5.6E-02	
			Average Amount (mmol)	0.00994	5.76E-05	0.0	0.00102	0.00216	0.0110
	02-Dec-04	1	2	4.6	0.160	<0.02	0.63	0.32	
			3	2.3	0.187	<0.02	0.68	0.35	
			4	2.3	0.210	<0.02	0.81	0.37	
			Average Conc. (mg/L)	3.1	0.19	0.00	0.71	0.35	
			Standard Deviation (mg/L)	1.3E+00	2.5E-02	0.0E+00	9.3E-02	2.7E-02	
			Average Amount (mmol)	0.00243	1.98E-04	0.0	0.00466	0.00342	0.00729

TABLE 3a: SUMMARY OF ACTIVITY ASSAY TESTS CONDUCTED FOR DISSOLVED PHASE TREATMENT TEST
EZVI Laboratory Treatability Study

SiREM

TREATMENT	DATE	day	REPLICATE	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/L
	03-Dec-04	2	2	1.6	0.197	<0.02	0.89	0.31	
			3	1.0	0.205	<0.02	0.81	0.27	
			4	0.33	0.213	<0.02	0.92	0.24	
			Average Conc. (mg/L)	1.0	0.21	0.00	0.87	0.27	
			Standard Deviation (mg/L)	6.2E-01	8.0E-03	0.0E+00	5.6E-02	3.2E-02	
			Average Amount (mmol)	7.58E-04	2.18E-04	0.0	0.00575	0.00272	0.00672
	06-Dec-04	5	2	0.02	0.180	<0.02	0.83	0.18	
			3	0.03	0.214	<0.02	0.76	0.15	
			4	0.01	0.187	<0.02	0.84	0.17	
			Average Conc. (mg/L)	0.02	0.19	0.00	0.81	0.16	
			Standard Deviation (mg/L)	1.3E-02	1.8E-02	0.0E+00	4.4E-02	1.6E-02	
			Average Amount (mmol)	1.77E-05	2.06E-04	0.0	0.00532	0.00163	0.00554
	07-Dec-04	6	2	0.01	0.173	0.01	0.64	0.12	
			3	0.01	0.185	0.0094	0.73	0.14	
			4	0.06	0.187	0.0088	0.85	0.18	
			Average Conc. (mg/L)	0.03	0.18	0.01	0.74	0.15	
			Standard Deviation (mg/L)	2.9E-02	7.8E-03	6.0E-04	1.0E-01	2.8E-02	
			Average Amount (mmol)	2.22E-05	1.93E-04	1.647E-05	0.00487	0.00144	0.00511

Notes:

baseline samples taken from bulk water TCE - trichlorethylene

cis-1,2-DCE - cis-1,2-dichloroethene VC - vinyl chloride

mg/L - milligrams per liter VOC -volatile organic carbon

mmol/bottle - millimole per bottle ZVI - zero valent iron

NA - not available -- - not analyzed/not applicable

ND - non detect > - compound exceeded calibration limits of the instrument

TABLE 3b: SUMMARY OF ACTIVITY ASSAY TESTS CONDUCTED FOR DNAPL PHASE TREATMENT TESTS
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/L
20 mg/L TCE with 10 g/L nZVI	01-Feb-05	0	baseline water ¹	20	<1	<1	<1	<1	
			Average Conc. (mg/L)	20	0.00	0.00	0.00	0.00	
			Average Amount (mmol)	0.0160	0	0	0	0	0.0160
	01-Feb-05	0.04	13	19	<0.02	<0.02	<1	0.50	
			14	18	<0.02	<0.02	<1	<1	
			Average Conc. (mg/L)	19	0.00	0.00	0.00	0.3	
			Standard Deviation (mg/L)	5.7E-01	0.0E+00	0.0E+00	0.0E+00	3.5E-01	
			Average Amount (mmol)	0.0148	0	0	0	0.00248	0.0173
	01-Feb-05	0.08	13	18	<0.02	<0.02	<1	<1	
			14	16	<0.02	<0.02	<1	<1	
			Average Conc. (mg/L)	17	0.0	0.00	0.0	0.0	
			Standard Deviation (mg/L)	1.4E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	
			Average Amount (mmol)	0.0134	0	0	0	0	0.0134
	01-Feb-05	0.25	13	16	<0.02	<0.02	0.48	0.30	
			14	17	<0.02	<0.02	0.43	0.40	
			Average Conc. (mg/L)	17	0.0	0.00	0.5	0.35	
			Standard Deviation (mg/L)	1.2E+00	0.0E+00	0.0E+00	3.3E-02	7.1E-02	
			Average Amount (mmol)	0.0133	0	0	0.00300	0.00347	0.0197
	02-Feb-05	1	13	12	<0.02	<0.02	0.88	<0.02	
			14	10	<0.02	<0.02	0.78	0.03	
			Average Conc. (mg/L)	11	0.00	0.00	0.83	0.0	
			Standard Deviation (mg/L)	1.8E+00	0.0E+00	0.0E+00	6.9E-02	2.1E-02	
			Average Amount (mmol)	0.00889	0	0	0.00545	1.49E-04	0.0145

TABLE 3b: SUMMARY OF ACTIVITY ASSAY TESTS CONDUCTED FOR DNAPL PHASE TREATMENT TESTS
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/L
	04-Feb-05	3	13	7.2	<0.02	<0.02	1.4	0.44	
			14	2.7	<0.02	<0.02	1.1	0.28	
			Average Conc. (mg/L)	4.9	0.0	0.00	1.2	0.36	
			Standard Deviation (mg/L)	3.2E+00	0.0E+00	0.0E+00	2.6E-01	1.1E-01	
			Average Amount (mmol)	0.00393	0	0	0.00815	0.00361	0.0157
	08-Feb-05	7	13	0.19	0.27	<0.02	1.1	0.25	
			14	0.18	0.25	<0.02	0.88	0.19	
			Average Conc. (mg/L)	0	0.3	0.00	0.98	0.22	
			Standard Deviation (mg/L)	5.1E-03	1.7E-02	0.0E+00	1.3E-01	4.8E-02	
			Average Amount (mmol)	1.45E-04	2.76E-04	0	0.00642	0.00218	0.00902

Notes:

- ¹ baseline samples taken from bottle #13
- baseline samples taken from bulk water
- cis-1,2-DCE - cis-1,2-dichloroethene
- mg/L - milligrams per liter
- mmol/bottle - millimole per bottle
- NA - not available
- ND - non detect
- TCE - trichlorethylene
- VC - vinyl chloride
- VOC -volatile organic carbon
- nZVI - nanoscale zero valent iron
- - not analyzed/not applicable
- > - compound exceeded calibration limits of the instrument

**TABLE 4: SUMMARY OF CHLORIDE, LACTATE, PH, AND DOC RESULTS FOR DISSOLVED PHASE
TREATMENT TESTS**
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Lactate mg/L	Chloride mg/L	pH (paper)	pH (meter)	DOC mg/L
Sterile Control	14-Dec-04	0	SC-1	2.5	1.3	--	--	11
			SC-2	--	--	--	--	--
			SC-3	--	--	--	--	--
			Average Conc.	2.5	1.3	--	--	11
	22-Dec-04	8	SC-1	6.8	147	6-7	--	--
			SC-2	3.8	166	6-7	--	--
			SC-3	3.4	152	6-7	--	--
			Average Conc.	4.7	155	--	--	--
	29-Dec-04	15	SC-1	2.2	142	6-7	--	--
			SC-2	5.7	146	6-7	--	--
			SC-3	1.3	138	6-7	--	--
			Average Conc.	3.1	142	--	--	--
	12-Jan-05	29	SC-1	<0.25	124	6	--	3.0
			SC-2	<0.25	123	6	--	<1
			SC-3	<0.25	131	6	--	<1
			Average Conc.	0.0	126	--	--	1.0
	9-Feb-05	57	SC-1	4.8	104	--	--	--
			SC-2	1.8	108	--	--	--
			SC-3	0.79	113	--	--	--
			Average Conc.	2.5	108	--	--	--
	6-Apr-05	113	SC-1	1.8	113	--	--	--
			SC-2	1.7	113	--	--	--
			SC-3	2.8	129	--	--	--
			Average Conc.	2.1	118	--	--	--

**TABLE 4: SUMMARY OF CHLORIDE, LACTATE, PH, AND DOC RESULTS FOR DISSOLVED PHASE
TREATMENT TESTS**
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Lactate	Chloride	pH (paper)	pH (meter)	DOC
				mg/L	mg/L			mg/L
Active Control	14-Dec-04	0	AC-1	1.7	0.79	--	--	--
			AC-2	--	--	--	--	--
			AC-3	--	--	--	--	--
			Average Conc.	1.7	0.79	--	--	--
	22-Dec-04	8	AC-1	14.7	10	6-7	--	--
			AC-2	4.7	5.4	6-7	--	--
			AC-3	4.2	4.2	6-7	--	--
			Average Conc.	7.9	6.6	--	--	--
	29-Dec-04	15	AC-1	1.2	6.6	7	--	--
			AC-2	1.1	3.4	7	--	--
			AC-3	1.0	2.9	7	--	--
			Average Conc.	1.1	4.3		--	--
	12-Jan-05	29	AC-1	0.13	3.0	6	--	<1
			AC-2	7.7	7.7	6	--	<1
			AC-3	7.8	9.0	6	--	<1
			Average Conc.	5.2	6.6		--	0.0
	14-Jan-05	31	AC-1	--	--	--	5.53	--
			AC-2	--	--	--	--	--
			AC-3	--	--	--	--	--
			Average Conc.	--	--	--	--	--
	9-Feb-05	57	AC-1	2.70	4.6	--	--	--
			AC-2	2.2	3.6	--	--	--
			AC-3	1.6	2.5	--	--	--
			Average Conc.	2.2	3.6	--	--	--
	6-Apr-05	113	AC-1	1.8	5.9	--	--	<2
			AC-2	2.2	7.0	--	--	--
			AC-3	3.0	4.1	--	--	--
			Average Conc.	2.3	5.7	--	--	--

**TABLE 4: SUMMARY OF CHLORIDE, LACTATE, PH, AND DOC RESULTS FOR DISSOLVED PHASE
TREATMENT TESTS**
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Lactate	Chloride	pH (paper)	pH (meter)	DOC
				mg/L	mg/L			mg/L
EZVI + KB-1™	14-Dec-04	0	EZVI +KB-1™-1	--	--	--	--	--
			EZVI +KB-1™-2	--	--	--	--	--
			EZVI +KB-1™-3	3.7	130	--	--	--
			Average Conc.	3.7	130	--	--	--
	22-Dec-04	8	EZVI +KB-1™-1	0.35	110	6-7	--	--
			EZVI +KB-1™-2	16	134	6-7	--	--
			EZVI +KB-1™-3	8.3	86	6-7	--	--
			Average Conc.	8.3	110	--	--	--
	29-Dec-04	15	EZVI +KB-1™-1	5.8	201	7	--	--
			EZVI +KB-1™-2	6.7	255	7	--	--
			EZVI +KB-1™-3	4.9	171	7	--	--
			Average Conc.	5.8	209	--	--	--
	12-Jan-05	29	EZVI +KB-1™-1	5.4	446	3	--	16
			EZVI +KB-1™-2	3.2	574	3	--	10
			EZVI +KB-1™-3	3.5	467	3	--	5.4
			Average Conc.	4.1	495	--	--	10
	7-Feb-05	55	buffered to a target of pH 7					
	9-Feb-05	57	EZVI +KB-1™-1	5.4	648	--	6.18	--
			EZVI +KB-1™-2	4.7	654	--	--	--
			EZVI +KB-1™-3	12	652	--	--	--
			Average Conc.	7.4	651	--	--	--
	15-Feb-05	63	buffered to pH 7 and re-bioaugmented with KB-1™ culture					
	15-Feb-05	63	EZVI +KB-1™-1	--	--	--	--	--
			EZVI +KB-1™-2	--	--	--	7.33	--
			EZVI +KB-1™-3	--	--	--	--	--
			Average Conc.	--	--	--	--	--
	1-Mar-05	77	EZVI +KB-1™-1	--	--	--	--	--
			EZVI +KB-1™-2	--	--	--	7.77	--
			EZVI +KB-1™-3	--	--	--	--	--
			Average Conc.	--	--	--	--	--
	9-Mar-05	85	EZVI +KB-1™-1	--	--	--	--	--
			EZVI +KB-1™-2	--	--	--	8.55	--
			EZVI +KB-1™-3	--	--	--	--	--
			Average Conc.	--	--	--	--	--
	6-Apr-05	113	EZVI +KB-1™-1	6.9	806	--	--	15.90
			EZVI +KB-1™-2	8.3	815	--	--	--
			EZVI +KB-1™-3	5.7	806	--	--	--
			Average Conc.	6.9	809	--	--	--

**TABLE 4: SUMMARY OF CHLORIDE, LACTATE, PH, AND DOC RESULTS FOR DISSOLVED PHASE
TREATMENT TESTS**
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Lactate mg/L	Chloride mg/L	pH (paper)	pH (meter)	DOC mg/L
Sterile EZVI + KB-1™	14-Dec-04	0	St EZVI+KB-1™ -1	3.9	155	--	--	<1
			St EZVI+KB-1™ -2	--	--	--	--	
			St EZVI+KB-1™ -3	--	--	--	--	
			Average Conc.	3.9	155	--	--	ND
	22-Dec-04	8	St EZVI+KB-1™ -1	3.8	270	6-7	--	--
			St EZVI+KB-1™ -2	11.5	334	6-7	--	--
			St EZVI+KB-1™ -3	6.0	331	6-7	--	--
			Average Conc.	7.1	312	--	--	--
	29-Dec-04	15	St EZVI+KB-1™ -1	7.5	323	6-7	--	--
			St EZVI+KB-1™ -2	6.8	455	6-7	--	--
			St EZVI+KB-1™ -3	4.4	361	6-7	--	--
			Average Conc.	6.2	380	--	--	--
	12-Jan-05	29	St EZVI+KB-1™ -1	2.2	740	3	--	22
			St EZVI+KB-1™ -2	<0.25	829	3	--	14
			St EZVI+KB-1™ -3	<0.25	502	3	--	14
			Average Conc.	0.74	690	--	--	17
	7-Feb-05	55	buffered to a tareget of pH 7					
	9-Feb-05	57	St EZVI+KB-1™ -1	3.5	734	--	6.10	--
			St EZVI+KB-1™ -2	7.1	835	--	--	--
			St EZVI+KB-1™ -3	7.0	686	--	--	--
			Average Conc.	5.9	752	--	--	--
	15-Feb-05	63	buffered to pH 7 and re-bioaugmented with KB-1™ culture					
	15-Feb-05	63	St EZVI+KB-1™ -1	--	--	--	--	--
			St EZVI+KB-1™ -2	--	--	--	7.17	--
			St EZVI+KB-1™ -3	--	--	--	--	--
			Average Conc.	--	--	--	--	--
	1-Mar-05	77	St EZVI+KB-1™ -1	--	--	--	--	--
			St EZVI+KB-1™ -2	--	--	--	6.91	--
			St EZVI+KB-1™ -3	--	--	--	--	--
			Average Conc.	--	--	--	--	--
	6-Apr-05	113	St EZVI+KB-1™ -1	7.3	1074	--	--	42.50
			St EZVI+KB-1™ -2	11	1085	--	--	--
			St EZVI+KB-1™ -3	13	938	--	--	--
			Average Conc.	11	1033	--	--	--

TABLE 4: SUMMARY OF CHLORIDE, LACTATE, PH, AND DOC RESULTS FOR DISSOLVED PHASE TREATMENT TESTS
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Lactate mg/L	Chloride mg/L	pH (paper)	pH (meter)	DOC mg/L
Emulsion + KB-1™	14-Dec-04	0	Emulsion + KB-1™ -1	1.7	0.86		--	<1
			Emulsion + KB-1™ -2	--	--	--	--	--
			Emulsion + KB-1™ -3	--	--	--	--	--
			Average Conc.	1.7	0.86		--	ND
	22-Dec-04	8	Emulsion + KB-1™ -1	6.1	17	7	--	--
			Emulsion + KB-1™ -2	7.0	16	7	--	--
			Emulsion + KB-1™ -3	3.4	13	7	--	--
			Average Conc.	5.5	15	--	--	--
	29-Dec-04	15	Emulsion + KB-1™ -1	6.0	16	7	--	--
			Emulsion + KB-1™ -2	4.9	15	7	--	--
			Emulsion + KB-1™ -3	4.3	15	7	--	--
			Average Conc.	5.0	15	--	--	--
	12-Jan-05	29	Emulsion + KB-1™ -1	3.8	16	6	--	8.2
			Emulsion + KB-1™ -2	1.0	12	6	--	5.9
			Emulsion + KB-1™ -3	3.5	12	6	--	6.6
			Average Conc.	2.8	13	--	--	6.9
	14-Jan-05	31	Emulsion + KB-1™ -1	3.8	--	--	--	--
			Emulsion + KB-1™ -2	1.0	--	--	5.35	--
			Emulsion + KB-1™ -3	3.5	--	--	--	--
			Average Conc.	2.8	--	--	--	--
	7-Feb-05	55	buffered all reps to a target of pH 7					
	9-Feb-05	57	Emulsion + KB-1™ -1	4.7	14	--	6.69	--
			Emulsion + KB-1™ -2	25.9	13	--	--	--
			Emulsion + KB-1™ -3	12.1	11	--	--	--
			Average Conc.	14.2	12	--	--	--
	15-Feb-05	63	buffered to pH 7 and re-bioaugmented with KB-1™ culture					
	15-Feb-05	63	Emulsion + KB-1™ -1	--	--	--	--	--
			Emulsion + KB-1™ -2	--	--	--	7.21	--
			Emulsion + KB-1™ -3	--	--	--	--	--
			Average Conc.	--	--	--	--	--
	1-Mar-05	77	Emulsion + KB-1™ -1	--	--	--	--	--
			Emulsion + KB-1™ -2	--	--	--	6.95	--
			Emulsion + KB-1™ -3	--	--	--	--	--
			Average Conc.	--	--	--	--	--
	9-Mar-05	85	Emulsion + KB-1™ -1	--	--	--	7.46	--
			Emulsion + KB-1™ -2	--	--	--	--	--
			Emulsion + KB-1™ -3	--	--	--	--	--
			Average Conc.	--	--	--	--	--
	6-Apr-05	113	Emulsion + KB-1™ -1	90	47	--	7.06	--
			Emulsion + KB-1™ -2	95	40	--	6.99	45.90
			Emulsion + KB-1™ -3	40	167	--	6.82	25.50
			Average Conc.	75	85	--	--	--

**TABLE 4: SUMMARY OF CHLORIDE, LACTATE, PH, AND DOC RESULTS FOR DISSOLVED PHASE
TREATMENT TESTS**
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Lactate mg/L	Chloride mg/L	pH (paper)	pH (meter)	DOC mg/L
ST + Emulsion + KB-1TM	14-Dec-04	0	St Em + KB-1 TM -1	2.2	1.2	--	--	<1
			St Em + KB-1 TM -2	--	--	--	--	--
			St Em + KB-1 TM -3	--	--	--	--	--
			Average Conc.	2.2	1.2	--	--	ND
	22-Dec-04	8	St Em + KB-1 TM -1	4.3	143	7	--	--
			St Em + KB-1 TM -2	10.2	157	7	--	--
			St Em + KB-1 TM -3	7.5	147	7	--	--
			Average Conc.	7.3	149		--	--
	29-Dec-04	15	St Em + KB-1 TM -1	4.4	131	7	--	--
			St Em + KB-1 TM -2	4.6	151	7	--	--
			St Em + KB-1 TM -3	3.4	159	7	--	--
			Average Conc.	4.2	147		--	--
	12-Jan-05	29	St Em + KB-1 TM -1	0.70	135	6	--	6.3
			St Em + KB-1 TM -2	1.3	149	6	--	4.5
			St Em + KB-1 TM -3	1.3	155	6	--	2.5
			Average Conc.	1.1	147	--	--	4.4
	7-Feb-05	55	buffered all reps to a tareget of pH 7					
	9-Feb-05	57	St Em + KB-1 TM -1	3.9	110	--	6.63	--
			St Em + KB-1 TM -2	3.9	111	--	--	--
			St Em + KB-1 TM -3	2.2	113	--	--	--
			Average Conc.	3.3	111	--	--	--
	15-Feb-05	63	buffered to pH 7 and re-bioaugmented with KB-1TM culture					
	15-Feb-05	63	St Em + KB-1 TM -1	--	--	--	7.14	--
			St Em + KB-1 TM -2	--	--	--		--
			St Em + KB-1 TM -3	--	--	--		--
			Average Conc.	--	--	--		--
	6-Apr-05	113	St Em + KB-1 TM -1	10	230	--	--	28.70
			St Em + KB-1 TM -2			--	--	--
			St Em + KB-1 TM -3			--	--	--
			Average Conc.	10.3	230	--	--	--

**TABLE 4: SUMMARY OF CHLORIDE, LACTATE, PH, AND DOC RESULTS FOR DISSOLVED PHASE
TREATMENT TESTS**
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Lactate mg/L	Chloride mg/L	pH (paper)	pH (meter)	DOC mg/L
ZVI+KB-1™	14-Dec-04	0	ZVI + KB-1™ -1	3.1	2.3		--	<1
			ZVI + KB-1™ -2	--	--	--	--	
			ZVI + KB-1™ -3	--	--	--	--	
			Average Conc.	3.1	2.3		--	ND
	22-Dec-04	8	ZVI + KB-1™ -1	11.2	944	7	--	--
			ZVI + KB-1™ -2	6.0	940	7	--	--
			ZVI + KB-1™ -3	4.6	940	7	--	--
			Average Conc.	7.3	942		--	--
	29-Dec-04	15	ZVI + KB-1™ -1	5.1	894	7	--	--
			ZVI + KB-1™ -2	5.3	992	6	--	--
			ZVI + KB-1™ -3	5.4	898	6	--	--
			Average Conc.	5.2	928		--	--
	12-Jan-05	29	ZVI + KB-1™ -1	1.2	839	3	--	3.0
			ZVI + KB-1™ -2	1.2	871	3	--	3.4
			ZVI + KB-1™ -3	0.52	845	3	--	2.6
			Average Conc.	1.0	852		--	3.0
	7-Feb-05	55	buffered all reps to a target of pH 7					
	9-Feb-05	57	ZVI + KB-1™ -1	2.6	742	--	6.35	--
			ZVI + KB-1™ -2	2.4	703	--	--	--
			ZVI + KB-1™ -3	Bad Sample		--	--	--
			Average Conc.	1.6	722	--	--	--
	15-Feb-05	63	buffered to pH 7 and re-bioaugmented with KB-1™ culture					
	15-Feb-05	63	ZVI + KB-1™ -1	--	--	--	6.93	--
			ZVI + KB-1™ -2	--	--	--	--	--
			ZVI + KB-1™ -3	--	--	--	--	--
			Average Conc.	--	--	--	--	--
	6-Apr-05	113	ZVI + KB-1™ -1	5.9	821	--	--	20.50
			ZVI + KB-1™ -2	5.3	826	--	--	--
			ZVI + KB-1™ -3	4.8	1060	--	--	--
			Average Conc.	5.3	903	--	--	--

TABLE 4: SUMMARY OF CHLORIDE, LACTATE, PH, AND DOC RESULTS FOR DISSOLVED PHASE TREATMENT TESTS
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Lactate mg/L	Chloride mg/L	pH (paper)	pH (meter)	DOC mg/L
Sterile ZVI + KB-1™	14-Dec-04	0	St ZVI + KB-1™ -1	2.0	1.3	--	--	<1
			St ZVI + KB-1™ -2	--	--	--	--	
			St ZVI + KB-1™ -3	--	--	--	--	
			Average Conc.	2.0	1.3	--	--	ND
	22-Dec-04	8	St ZVI + KB-1™ -1	4.5	1007	7	--	--
			St ZVI + KB-1™ -2	5.4	1101	7	--	--
			St ZVI + KB-1™ -3	4.0	1115	7	--	--
			Average Conc.	4.6	1074	--	--	--
	29-Dec-04	15	St ZVI + KB-1™ -1	5.3	1056	6	--	--
			St ZVI + KB-1™ -2	6.6	1082	6	--	--
			St ZVI + KB-1™ -3	7.4	1118	6	--	--
			Average Conc.	6.4	1085	--	--	--
	12-Jan-05	29	St ZVI + KB-1™ -1	1.4	885	3	--	2.9
			St ZVI + KB-1™ -2	0.3	1001	3	--	7.4
			St ZVI + KB-1™ -3	1.5	974	3	--	<1
			Average Conc.	1.1	953	--	--	3.4
	14-Jan-05	31	St ZVI + KB-1™ -1	--	--	--	--	--
			St ZVI + KB-1™ -2	--	--	--	--	--
			St ZVI + KB-1™ -3	--	--	--	5.27	--
			Average Conc.	--	--	--	--	--
	7-Feb-05	55	buffered all reps to a target of pH 7					
	9-Feb-05	57	St ZVI + KB-1™ -1	2.2	727	--	6.21	--
			St ZVI + KB-1™ -2	2.2	818	--	--	--
			St ZVI + KB-1™ -3	2.3	850	--	--	--
			Average Conc.	2.2	798	--	--	--
	15-Feb-05	63	buffered to pH 7 and re-bioaugmented with KB-1™ culture					
	15-Feb-05	63	St ZVI + KB-1™ -1	--	--	--	--	--
			St ZVI + KB-1™ -2	--	--	--	--	--
			St ZVI + KB-1™ -3	--	--	--	6.9	--
			Average Conc.	--	--	--	--	--
	6-Apr-05	113	St ZVI + KB-1™ -1	5.8	1016	--	--	22.70
			St ZVI + KB-1™ -2	--	--	--	--	--
			St ZVI + KB-1™ -3	5.2	1033	--	--	--
			Average Conc.	5.5	1025	--	--	23

Notes:

DOC - dissolved organic carbon
Em - Emulsion
mg/L - milligrams per liter
ND - non detect
SC - Sterile Control

ZVI - zero valent iron
-- - not analyzed/not applicable
EZVI - emulsified zero-valent iron
St - Sterile
AC - Active Control

TABLE 5: SUMMARY OF VOC DATA FROM DISSOLVED PHASE STERILE CONTROL
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
Sterile Control	14-Dec-04	0	baseline water ¹	556	<1	<1	<1	<1	--
			baseline water ²	561	<1	<1	<1	<1	--
			Average Conc. (mg/L)	558	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.4E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.445	ND	ND	ND	ND	0.445
	15-Dec-04	1	SC-1	924	<1	<1	<1	<1	--
			SC-2	997	<1	<1	<1	<1	--
			SC-3	1005	<1	<1	<1	<1	--
			Average Conc. (mg/L)	975	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	4.5E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.778	ND	ND	ND	ND	0.778
	17-Dec-04	3	SC-1	--	--	--	--	--	--
			SC-2	908	<1	<1	<1	<1	--
			SC-3	929	<1	<1	<1	<1	--
			Average Conc. (mg/L)	919	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.5E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.733	ND	ND	ND	ND	0.733
	21-Dec-04	7	SC-1	936	<1	<1	<1	<1	--
			SC-2	914	<1	<1	<1	<1	--
			SC-3	639	<1	<1	<1	<1	--
			Average Conc. (mg/L)	830	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.7E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.662	ND	ND	ND	ND	0.662
	29-Dec-04	15	SC-1	906	<1	<1	<1	<1	--
			SC-2	822	<1	<1	<1	<1	--
			SC-3	864	<1	<1	<1	<1	--
			Average Conc. (mg/L)	864	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	4.2E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.689	ND	ND	ND	ND	0.689

TABLE 5: SUMMARY OF VOC DATA FROM DISSOLVED PHASE STERILE CONTROL
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
	12-Jan-05	29	SC-1	mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
			SC-2	805	<1	<1	<1	<1	--
			SC-3	844	<1	<1	<1	<1	--
			SC-3	na					--
			Average Conc. (mg/L)	825	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	2.8E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.658	ND	ND	ND	ND	0.658
	09-Feb-05	56	SC-1	843	<1	<1	<1	<1	--
			SC-2	813	<1	<1	<1	<1	--
			SC-3	865	<1	<1	<1	<1	--
			Average Conc. (mg/L)	840	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	2.6E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.670	ND	ND	ND	ND	0.670

Notes:

¹ baseline samples taken from replicate 1 after being open for 30 seconds

² baseline samples taken from replicate 2 after being open for 30 seconds

> - compound exceeded calibration limits of the instrument

SC - sterile control

NA - not available

cis-1,2-DCE - cis-1,2-dichloroethene

ND - non detect

mg/L - milligrams per liter

TCE - trichlorethylene

mmol/bottle - millimole per bottle

VC - vinyl chloride

-- - not analyzed/not applicable

VOC -volatile organic carbon

TABLE 6: SUMMARY OF VOC DATA FROM DISSOLVED PHASE ACTIVE CONTROL
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
Active Control	14-Dec-04	0	baseline water ¹	560	<1	<1	<1	<1	--
			baseline water ²	573	<1	<1	<1	<1	--
			Average Conc. (mg/L)	567	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	9.2E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Amount (mmol)	0.452	ND	ND	ND	ND	0.452
	15-Dec-04	1	AC-1	1040	<1	<1	<1	<1	--
			AC-2	1033	<1	<1	<1	<1	--
			AC-3	1018	<1	<1	<1	<1	--
			Average Conc. (mg/L)	1030	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.1E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.822	ND	ND	ND	ND	0.822
	17-Dec-04	3	AC-1	969	<1	<1	<1	<1	--
			AC-2	914	<1	<1	<1	<1	--
			AC-3	963	<1	<1	<1	<1	--
			Average Conc. (mg/L)	948	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.0E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.756	ND	ND	ND	ND	0.756
	21-Dec-04	7	AC-1	954	<1	<1	<1	<1	--
			AC-2	978	<1	<1	<1	<1	--
			AC-3	987	<1	<1	<1	<1	--
			Average Conc. (mg/L)	973	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.7E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.776	ND	ND	ND	ND	0.776
	29-Dec-04	15	AC-1	897	<1	<1	<1	<1	--
			AC-2	830	<1	<1	<1	<1	--
			AC-3	912	<1	<1	<1	<1	--
			Average Conc. (mg/L)	880	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	4.4E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.702	ND	ND	ND	ND	0.702
	12-Jan-05	29	AC-1	924	<1	<1	<1	<1	--
			AC-2	850	<1	<1	<1	<1	--
			AC-3	882	<1	<1	<1	<1	--
			Average Conc. (mg/L)	885	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.7E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.706	ND	ND	ND	ND	0.706
	09-Feb-05	56	AC-1	937	<1	<1	<1	<1	--
			AC-2	895	<1	<1	<1	<1	--
			AC-3	879	<1	<1	<1	<1	--
			Average Conc. (mg/L)	903	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.0E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.721	ND	ND	ND	ND	0.721

Notes:

¹ baseline samples taken from SC replicate 3 after being open for 1 minute and 10 seconds

² baseline samples taken from AC replicate 1 after being open for 1 minute and 10 seconds

> - compound exceeded calibration limits of the instrument

AC - active control

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

TCE - trichloroethylene

VC - vinyl chloride

VOC -volatile organic carbon

-- - not analyzed/not applicable

TABLE 7: SUMMARY OF VOC DATA FROM DISSOLVED PHASE OIL EMULSION + KB-1™
EZVI Laboratory Treatability Study

SIREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
Emulsion + KB-1™	14-Dec-04	0	baseline water ¹	556	<1	<1	<1	<1	--
			baseline water ²	561	<1	<1	<1	<1	--
			Average Conc. (mg/L)	372	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.4E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.297	ND	ND	ND	ND	0.297
	14-Dec-04	0.04	Emulsion + KB-1™ -1	243	<1	<1	<1	<1	--
			Emulsion + KB-1™ -2	349	<1	<1	<1	<1	--
			Emulsion + KB-1™ -3	194	<1	<1	<1	<1	--
			Average Conc. (mg/L)	262	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	7.9E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.209	ND	ND	ND	ND	0.209
	14-Dec-04	0.08	Emulsion + KB-1™ -1	324	<1	<1	<1	<1	--
			Emulsion + KB-1™ -2	167	<1	<1	<1	<1	--
			Emulsion + KB-1™ -3	739	<1	<1	<1	<1	--
			Average Conc. (mg/L)	410	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.0E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.327	ND	ND	ND	ND	0.327
	14-Dec-04	0.25	Emulsion + KB-1™ -1	114	<1	<1	<1	<1	--
			Emulsion + KB-1™ -2	321	<1	<1	<1	<1	--
			Emulsion + KB-1™ -3	305	<1	<1	<1	<1	--
			Average Conc. (mg/L)	247	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.2E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.197	ND	ND	ND	ND	0.197
	15-Dec-04	1	Emulsion + KB-1™ -1	176	<0.5	<0.5	<0.5	<0.5	--
			Emulsion + KB-1™ -2	164	<0.5	<0.5	<0.5	<0.5	--
			Emulsion + KB-1™ -3	193	<0.5	<0.5	<0.5	<0.5	--
			Average Conc. (mg/L)	178	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.4E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.142	ND	ND	ND	ND	0.142
	17-Dec-04	3	Emulsion + KB-1™ -1	136	<0.2	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -2	114	<0.2	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -3	145	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	131	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.6E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.105	ND	ND	ND	ND	1.0E-01
	21-Dec-04	7	Emulsion + KB-1™ -1	48	<0.2	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -2	147	<0.2	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -3	160	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	118	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	6.1E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.094	ND	ND	ND	ND	0.094
	29-Dec-04	15	Emulsion + KB-1™ -1	160	<0.2	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -2	248	<0.2	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -3	141	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	183	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	5.7E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.146	ND	ND	ND	ND	0.146
	12-Jan-05	29	Emulsion + KB-1™ -1	196	0.58	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -2	153	0.48	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -3	128	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	159	0.354	ND	ND	ND	--
			Standard Deviation (mg/L)	3.4E+01	3.1E-01	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.127	0.000376	ND	ND	ND	0.127
	26-Jan-05	43	Emulsion + KB-1™ -1	191	<0.2	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -2	279	<0.2	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -3	226	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	232	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	4.4E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.185	ND	ND	ND	ND	0.185
	07-Feb-05	54	Comment	buffered all replicates to a target of pH 7					

TABLE 7: SUMMARY OF VOC DATA FROM DISSOLVED PHASE OIL EMULSION + KB-1™
EZVI Laboratory Treatability Study

SIREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
	09-Feb-05	57	Emulsion + KB-1™ -1	mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
			Emulsion + KB-1™ -2	>400	1.7	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -3	>400	0.55	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -3	>400	0.60	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	400	0.95	ND	ND	ND	--
			Standard Deviation (mg/L)	0.0E+00	6.5E-01	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.319	0.00101	ND	ND	ND	0.320
	15-Feb-05	63	Emulsion + KB-1™ -1	>400	<0.2	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -2	>400	<0.2	<0.2	<0.2	<0.2	--
			Emulsion + KB-1™ -3	>400	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	400	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.319	ND	ND	ND	ND	0.319
	15-Feb-05	63	Comment	buffered all replicates to a target of pH 7 and re-bioaugmented with KB-1™ culture					
	16-Feb-05	64	Emulsion + KB-1™ -1	870	<1	<1	<1	<1	--
			Emulsion + KB-1™ -2	457	<1	<1	<1	<1	--
			Emulsion + KB-1™ -3	486	<1	<1	<1	<1	--
			Average Conc. (mg/L)	604	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	2.3E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.482	ND	ND	ND	ND	0.482
	23-Feb-05	71	Emulsion + KB-1™ -1	877	21	<1	<1	<1	--
			Emulsion + KB-1™ -2	323	1.2	<1	<1	<1	--
			Emulsion + KB-1™ -3	436	56	<1	<1	<1	--
			Average Conc. (mg/L)	545	26	ND	ND	ND	--
			Standard Deviation (mg/L)	2.9E+02	2.8E+01	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.435	0.0279	ND	ND	ND	0.463
	01-Mar-05	77	Emulsion + KB-1™ -1	928	20	<1	<1	<1	--
			Emulsion + KB-1™ -2	581	2.0	<1	<1	<1	--
			Emulsion + KB-1™ -3	636	190	<1	<1	<1	--
			Average Conc. (mg/L)	715	71	ND	ND	ND	--
			Standard Deviation (mg/L)	1.9E+02	1.0E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.570	0.0751	ND	ND	ND	0.645
	09-Mar-05	85	Emulsion + KB-1™ -1	945	20	<1	<1	<1	--
			Emulsion + KB-1™ -2	875	3.7	<1	<1	<1	--
			Emulsion + KB-1™ -3	591	232	<1	<1	<1	--
			Average Conc. (mg/L)	804	85	ND	ND	ND	--
			Standard Deviation (mg/L)	1.9E+02	1.3E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.641	0.0907	ND	ND	ND	0.732
	16-Mar-05	92	Emulsion + KB-1™ -1	894	20	<1	<1	<1	--
			Emulsion + KB-1™ -2	938	3.0	<1	<1	<1	--
			Emulsion + KB-1™ -3	491	269	<1	<1	<1	--
			Average Conc. (mg/L)	774	97	ND	ND	ND	--
			Standard Deviation (mg/L)	2.5E+02	1.5E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.617	0.104	ND	ND	ND	0.721
	23-Mar-05	99	Emulsion + KB-1™ -1	864	24	<1	<1	<1	--
			Emulsion + KB-1™ -2	958	24	<1	<1	<1	--
			Emulsion + KB-1™ -3	--	--	--	--	--	--
			Average Conc. (mg/L)	911	24	ND	ND	ND	--
			Standard Deviation (mg/L)	6.7E+01	2.4E-01	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.726	0.0253	ND	ND	ND	0.752
	01-Apr-05	108	Emulsion + KB-1™ -1	915	27	<1	<1	<1	--
			Emulsion + KB-1™ -2	953	4.7	<1	<1	<1	--
			Emulsion + KB-1™ -3	422	342	<1	<1	<1	--
			Average Conc. (mg/L)	763	125	ND	ND	ND	--
			Standard Deviation (mg/L)	3.0E+02	1.9E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.609	0.132	ND	ND	ND	0.741
	06-Apr-05	113	Emulsion + KB-1™ -1	850	35	<1	<1	<1	--
			Emulsion + KB-1™ -2	991	6.5	<1	<1	<1	--
			Emulsion + KB-1™ -3	505	326	<1	<1	<1	--
			Average Conc. (mg/L)	782	122	ND	ND	ND	--
			Standard Deviation (mg/L)	2.5E+02	1.8E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.624	0.130	ND	ND	ND	0.754

TABLE 7: SUMMARY OF VOC DATA FROM DISSOLVED PHASE OIL EMULSION + KB-1™
EZVI Laboratory Treatability Study

SIREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	13-Apr-05	120	Emulsion + KB-1™ -1	967	40	<1	<1	<1	--
			Emulsion + KB-1™ -2	263	2.9	<1	<1	<1	--
			Emulsion + KB-1™ -3	413	342	<1	<1	<1	--
			Average Conc. (mg/L)	548	128	ND	ND	ND	--
			Standard Deviation (mg/L)	3.7E+02	1.9E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.437	0.136	ND	ND	ND	0.573
	20-Apr-05	127	Emulsion + KB-1™ -1	815	35	<1	<1	<1	--
			Emulsion + KB-1™ -2	269	2.4	<1	<1	<1	--
			Emulsion + KB-1™ -3	340	1.4	<1	<1	<1	--
			Average Conc. (mg/L)	475	13	ND	ND	ND	--
			Standard Deviation (mg/L)	3.0E+02	1.9E+01	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.379	0.0136	ND	ND	ND	0.392
	27-Apr-05	134	Emulsion + KB-1™ -1	967	40	<1	<1	<1	--
			Emulsion + KB-1™ -2	761	6.3	<1	<1	<1	--
			Emulsion + KB-1™ -3	438	364	<1	<1	<1	--
			Average Conc. (mg/L)	722	137	ND	ND	ND	--
			Standard Deviation (mg/L)	2.7E+02	2.0E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.576	0.145	ND	ND	ND	0.721
	04-May-05	141	Emulsion + KB-1™ -1	842	36	<1	<1	<1	--
			Emulsion + KB-1™ -2	943	6.8	<1	<1	<1	--
			Emulsion + KB-1™ -3	429	341	<1	<1	<1	--
			Average Conc. (mg/L)	738	128	ND	ND	ND	--
			Standard Deviation (mg/L)	2.7E+02	1.9E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.588	0.136	ND	ND	ND	0.725
	11-May-05	148	Emulsion + KB-1™ -1	933	38	<1	<1	<1	--
			Emulsion + KB-1™ -2	956	4.4	<1	<1	<1	--
			Emulsion + KB-1™ -3	402	382	<1	<1	<1	--
			Average Conc. (mg/L)	764	142	ND	ND	ND	--
			Standard Deviation (mg/L)	3.1E+02	2.1E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.609	0.151	ND	ND	ND	0.760
	20-May-05	157	Emulsion + KB-1™ -1	1090	44	<1	<1	<1	--
			Emulsion + KB-1™ -2	1302	8.4	<1	<1	<1	--
			Emulsion + KB-1™ -3	464	548	<1	<1	<1	--
			Average Conc. (mg/L)	952	200	ND	ND	ND	--
			Standard Deviation (mg/L)	4.4E+02	3.0E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.759	0.213	ND	ND	ND	0.972
	26-May-05	163	Emulsion + KB-1™ -1	835	38	<1	<1	<1	--
			Emulsion + KB-1™ -2	911	5.8	<1	<1	<1	--
			Emulsion + KB-1™ -3	326	371	<1	<1	<1	--
			Average Conc. (mg/L)	691	138	ND	ND	ND	--
			Standard Deviation (mg/L)	3.2E+02	2.0E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.551	0.147	ND	ND	ND	0.698
	01-Jun-05	169	Emulsion + KB-1™ -1	933	41	<1	<1	<1	--
			Emulsion + KB-1™ -2	974	4.7	<1	<1	<1	--
			Emulsion + KB-1™ -3	392	381	<1	<1	<1	--
			Average Conc. (mg/L)	766	142	ND	ND	ND	--
			Standard Deviation (mg/L)	3.2E+02	2.1E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.611	0.151	ND	ND	ND	0.762
	08-Jun-05	176	Emulsion + KB-1™ -1	988	46	<1	<1	<1	--
			Emulsion + KB-1™ -2	976	61	<1	<1	<1	--
			Emulsion + KB-1™ -3	309	471	<1	<1	<1	--
			Average Conc. (mg/L)	758	193	ND	ND	ND	--
			Standard Deviation (mg/L)	3.9E+02	2.4E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.604	0.205	ND	ND	ND	0.809
	15-Jun-05	183	Emulsion + KB-1™ -1	992	42	<1	<1	<1	--
			Emulsion + KB-1™ -2	1018	7.2	<1	<1	<1	--
			Emulsion + KB-1™ -3	386	415	<1	<1	<1	--
			Average Conc. (mg/L)	799	154	ND	ND	ND	--
			Standard Deviation (mg/L)	3.6E+02	2.3E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.637	0.164	ND	ND	ND	0.801

TABLE 7: SUMMARY OF VOC DATA FROM DISSOLVED PHASE OIL EMULSION + KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	22-Jun-05	190	Emulsion + KB-1™ -1	944	39	<1	<1	<1	--
			Emulsion + KB-1™ -2	1003	3.3	<1	<1	<1	--
			Emulsion + KB-1™ -3	354	443	<1	<1	<1	--
			Average Conc. (mg/L)	767	162	ND	ND	ND	--
			Standard Deviation (mg/L)	3.6E+02	2.4E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.612	0.172	ND	ND	ND	0.784
	29-Jun-05	197	Emulsion + KB-1™ -1	945	40	<1	<1	<1	
			Emulsion + KB-1™ -2	1036	7.4	<1	<1	<1	
			Emulsion + KB-1™ -3	364	456	<1	<1	<1	
			Average Conc. (mg/L)	782	168	ND	ND	ND	--
			Standard Deviation (mg/L)	3.6E+02	2.5E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.624	0.178	ND	ND	ND	0.802
	08-Jul-05	206	Emulsion + KB-1™ -1	897	37	<1	<1	<1	
			Emulsion + KB-1™ -2	1035	4.0	<1	<1	<1	
			Emulsion + KB-1™ -3	259	478	<1	<1	<1	
			Average Conc. (mg/L)	731	173	ND	ND	ND	--
			Standard Deviation (mg/L)	4.1E+02	2.6E+02	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.583	0.184	ND	ND	ND	0.767

Notes:

¹ baseline samples taken from replicate 1 after being open for 30 seconds

² baseline samples taken from replicate 2 after being open for 30 seconds

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

TCE - trichlorethylene

VC - vinyl chloride

VOC -volatile organic carbon

-- - not analyzed/not applicable

> - compound exceeded calibration limits of the instrument

TABLE 8: SUMMARY OF VOC DATA FROM DISSOLVED PHASE STERILE OIL EMULSION + KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
Sterile + Emulsion + KB-1™	14-Dec-04	0	baseline water ¹	556	<1	<1	<1	<1	--
			baseline water ²	561	<1	<1	<1	<1	--
			Average Conc. (mg/L)	558	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.4E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.445	ND	ND	ND	ND	0.445
	14-Dec-04	0.04	Sterile Emulsion + KB-1™ -1	924	<1	<1	<1	<1	--
			Sterile Emulsion + KB-1™ -2	902	<1	<1	<1	<1	--
			Sterile Emulsion + KB-1™ -3	299	<1	<1	<1	<1	--
			Average Conc. (mg/L)	708	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.5E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.565	ND	ND	ND	ND	0.565
	14-Dec-04	0.08	Sterile Emulsion + KB-1™ -1	412	<1	<1	<1	<1	--
			Sterile Emulsion + KB-1™ -2	356	<1	<1	<1	<1	--
			Sterile Emulsion + KB-1™ -3	161	<1	<1	<1	<1	--
			Average Conc. (mg/L)	310	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.3E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.247	ND	ND	ND	ND	0.247
	14-Dec-04	0.25	Sterile Emulsion + KB-1™ -1	394	<1	<1	<1	<1	--
			Sterile Emulsion + KB-1™ -2	485	<1	<1	<1	<1	--
			Sterile Emulsion + KB-1™ -3	285	<1	<1	<1	<1	--
			Average Conc. (mg/L)	388	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.0E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.310	ND	ND	ND	ND	0.310
	15-Dec-04	1	Sterile Emulsion + KB-1™ -1	326	<0.5	<0.5	<0.5	<0.5	--
			Sterile Emulsion + KB-1™ -2	187	<0.5	<0.5	<0.5	<0.5	--
			Sterile Emulsion + KB-1™ -3	316	<0.5	<0.5	<0.5	<0.5	--
			Average Conc. (mg/L)	277	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	7.7E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.221	ND	ND	ND	ND	0.221
	17-Dec-04	3	Sterile Emulsion + KB-1™ -1	312	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -2	214	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -3	153	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	227	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	8.0E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.181	ND	ND	ND	ND	0.181
	21-Dec-04	7	Sterile Emulsion + KB-1™ -1	66	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -2	>400	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -3	>400	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	22	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.8E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.0177	ND	ND	ND	ND	0.018
	29-Dec-04	15	Sterile Emulsion + KB-1™ -1	>400	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -2	188	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -3	272	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	153	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.4E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.122	ND	ND	ND	ND	0.122
	12-Jan-05	29	Sterile Emulsion + KB-1™ -1	213	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -2	162	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -3	130	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	168	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	4.2E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.134	ND	ND	ND	ND	0.134

TABLE 8: SUMMARY OF VOC DATA FROM DISSOLVED PHASE STERILE OIL EMULSION + KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	26-Jan-05	43	Sterile Emulsion + KB-1™ -1	196	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -2	214	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -3	271	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	227	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.9E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.181	ND	ND	ND	ND	0.181
	07-Feb-05	55	Comment	buffered all replicates to a target of pH 7					
	09-Feb-05	57	Sterile Emulsion + KB-1™ -1	146	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -2	128	<0.2	<0.2	<0.2	<0.2	--
			Sterile Emulsion + KB-1™ -3	236	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	170	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	5.8E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.136	ND	ND	ND	ND	0.136
	16-Feb-05	63	Sterile Emulsion + KB-1™ -1	--	--	--	--	--	--
			Sterile Emulsion + KB-1™ -2	--	--	--	--	--	--
			Sterile Emulsion + KB-1™ -3	83	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	83	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	NA	NA	NA	NA	NA	--
			Average Total (mmoles)	0.0665	ND	ND	ND	ND	0.066
	15-Feb-05	63	Comment	buffered all replicates to a target of pH 7 and re-bioaugmented with KB-1™ culture					
	23-Feb-05	71	Sterile Emulsion + KB-1™ -1	--	--	--	--	--	--
			Sterile Emulsion + KB-1™ -2	--	--	--	--	--	--
			Sterile Emulsion + KB-1™ -3	123	<0.2	<0.2	<0.2	<0.2	--
			Average Conc. (mg/L)	123	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	NA	NA	NA	NA	NA	--
			Average Total (mmoles)	0.0979	ND	ND	ND	ND	0.098

Notes:

¹ baseline samples taken from replicate 1 after being open for 30 seconds

² baseline samples taken from replicate 2 after being open for 30 seconds

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

TCE - trichlorethylene

VC - vinyl chloride

VOC -volatile organic carbon

-- - not analyzed/not applicable

> - compound exceeded calibration limits of the instrument

replicates 1 and 2 sent to PSC on day 63 for methanol extractions

NA - not available

TABLE 9: SUMMARY OF VOC DATA FROM DISSOLVED PHASE ZVI + KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
ZVI+KB-1™	14-Dec-04	0	baseline water ¹	598	<1	<1	<1	<1	--
			baseline water ²	600	<1	<1	<1	<1	--
			Average Conc. (mg/L)	599	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.4E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.478	ND	ND	ND	ND	0.478
	14-Dec-04	0.04	ZVI + KB-1™ -1	570	<1	<1	<1	<1	--
			ZVI + KB-1™ -2	253	<1	<1	<1	<1	--
			ZVI + KB-1™ -3	410	<1	<1	<1	<1	--
			Average Conc. (mg/L)	411	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.6E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.328	ND	ND	ND	ND	0.328
	14-Dec-04	0.08	ZVI + KB-1™ -1	653	1.7	<1	1.9	6.1	--
			ZVI + KB-1™ -2	604	1.5	<1	1.7	4.8	--
			ZVI + KB-1™ -3	563	1.4	<1	1.9	5.4	--
			Average Conc. (mg/L)	607	1.5	ND	1.8	5.4	--
			Standard Deviation (mg/L)	4.5E+01	1.1E-01	0.0E+00	8.7E-02	6.5E-01	--
			Average Total (mmoles)	0.484	0.00164	ND	0.0119	0.0536	0.551
	14-Dec-04	0.25	ZVI + KB-1™ -1	694	3.4	<1	4.0	13	--
			ZVI + KB-1™ -2	682	3.8	<1	4.9	14	--
			ZVI + KB-1™ -3	608	4.0	<1	5.0	18	--
			Average Conc. (mg/L)	661	3.7	ND	4.6	15	--
			Standard Deviation (mg/L)	4.6E+01	3.3E-01	0.0E+00	5.2E-01	2.8E+00	--
			Average Total (mmoles)	0.527	0.00396	ND	0.0305	0.151	0.713
	15-Dec-04	1	ZVI + KB-1™ -1	178	6.4	<0.5	15	31	--
			ZVI + KB-1™ -2	219	7.1	<0.5	17	33	--
			ZVI + KB-1™ -3	241	7.1	<0.5	21	33	--
			Average Conc. (mg/L)	212	6.9	ND	18	33	--
			Standard Deviation (mg/L)	3.2E+01	4.1E-01	0.0E+00	2.8E+00	1.1E+00	--
			Average Total (mmoles)	0.169	0.00730	ND	0.116	0.323	0.615
	17-Dec-04	3	ZVI + KB-1™ -1	1.9	7.5	0.34	24	21	--
			ZVI + KB-1™ -2	68	7.5	0.32	25	21	--
			ZVI + KB-1™ -3	77	7.5	0.32	30	21	--
			Average Conc. (mg/L)	49	7.5	0.33	26	21	--
			Standard Deviation (mg/L)	4.1E+01	2.9E-02	1.1E-02	3.2E+00	3.4E-01	--
			Average Total (mmoles)	0.0392	0.00799	5.73E-04	0.174	0.206	0.428
	21-Dec-04	7	ZVI + KB-1™ -1	9.6	6.5	0.34	33	5.0	--
			ZVI + KB-1™ -2	16	7.3	0.36	53	13	--
			ZVI + KB-1™ -3	9.4	7.2	0.36	42	6.1	--
			Average Conc. (mg/L)	12	7.0	0.35	43	8.2	--
			Standard Deviation (mg/L)	3.8E+00	4.5E-01	1.3E-02	9.6E+00	4.6E+00	--
			Average Total (mmoles)	0.00929	0.00745	6.18E-04	0.280	0.0808	0.378
	29-Dec-04	15	ZVI + KB-1™ -1	0.52	4.5	0.47	29	4.1	--
			ZVI + KB-1™ -2	0.38	5.0	<0.2	25	3.5	--
			ZVI + KB-1™ -3	0.29	4.9	0.42	30	4.4	--
			Average Conc. (mg/L)	0.40	4.8	0.29	28	4.0	--
			Standard Deviation (mg/L)	1.1E-01	2.9E-01	2.6E-01	2.6E+00	4.9E-01	--
			Average Total (mmoles)	3.15E-04	0.00509	5.16E-04	0.186	0.0396	0.231
	07-Jan-05	24	ZVI + KB-1™ -1	0.73	2.8	0.32	27	3.8	--
			ZVI + KB-1™ -2	4.0	4.3	0.28	28	3.7	--
			ZVI + KB-1™ -3	1.7	3.6	0.33	25	3.3	--
			Average Conc. (mg/L)	2.1	3.6	0.31	27	3.6	--
			Standard Deviation (mg/L)	1.7E+00	7.8E-01	2.5E-02	1.4E+00	2.8E-01	--
			Average Total (mmoles)	0.00169	0.00380	5.42E-04	0.175	0.0355	0.217

TABLE 9: SUMMARY OF VOC DATA FROM DISSOLVED PHASE ZVI + KB-1TM
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	12-Jan-05	29	ZVI + KB-1 TM -1	2.4	2.9	<0.2	25	3.6	--
			ZVI + KB-1 TM -2	--	--	--	--	--	--
			ZVI + KB-1 TM -3	3.1	3.0	<0.2	19	2.3	--
			Average Conc. (mg/L)	2.8	3.0	ND	22	2.9	--
			Standard Deviation (mg/L)	5.2E-01	6.5E-02	0.0E+00	4.0E+00	9.0E-01	--
			Average Total (mmoles)	0.00219	0.00316	ND	0.144	0.0289	0.178
	07-Feb-05	55	Comment	buffered all replicates to a target of pH 7					
	09-Feb-05	57	ZVI + KB-1 TM -1	0.63	0.7	0.24	12	1.4	--
			ZVI + KB-1 TM -2	<0.2	1.5	0.31	14	1.7	--
			ZVI + KB-1 TM -3	--	--	--	--	--	--
			Average Conc. (mg/L)	0.3	1.1	0.27	13	1.6	--
			Standard Deviation (mg/L)	4.4E-01	5.4E-01	4.8E-02	1.4E+00	2.6E-01	--
			Average Total (mmoles)	2.50E-04	0.00113	4.77E-04	0.0870	0.0155	0.104
	15-Feb-05	63	ZVI + KB-1 TM -1	1.3	0.42	<0.2	10	1.1	--
			ZVI + KB-1 TM -2	1.3	1.0	<0.2	14	1.6	--
			ZVI + KB-1 TM -3	--	--	--	--	--	--
			Average Conc. (mg/L)	1.3	0.7	ND	12	1.3	--
			Standard Deviation (mg/L)	3.1E-02	4.0E-01	0.0E+00	2.9E+00	3.7E-01	--
			Average Total (mmoles)	0.00102	0.000744	ND	0.0801	0.0134	0.095
	15-Feb-05	63	Comment	buffered all replicates to a target of pH 7 and re-bioaugmented with KB-1 TM culture					
	23-Feb-05	71	ZVI + KB-1 TM -1	<0.2	<0.2	<0.2	9.4	1.1	--
			ZVI + KB-1 TM -2	<0.2	0.35	0.22	10	1.2	--
			ZVI + KB-1 TM -3	--	--	--	--	--	--
			Average Conc. (mg/L)	ND	0.2	0.11	10	1.1	--
			Standard Deviation (mg/L)	0.0E+00	2.5E-01	1.6E-01	6.3E-01	1.1E-01	--
			Average Total (mmoles)	ND	1.85E-04	1.94E-04	0.0650	0.0113	0.077

Notes:

¹ baseline samples taken from AC replicate 2 after being open for 23 seconds

² baseline samples taken from AC replicate 3 after being open for 23 seconds

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

TCE - trichloroethylene

VC - vinyl chloride

VOC -volatile organic carbon

ZVI - zero valent iron

-- - not analyzed/not applicable

> - compound exceeded calibration limits of the instrument

replicates 3 sent to PSC on day 57 for external VOC analysis

TABLE 10: SUMMARY OF VOC DATA FROM DISSOLVED PHASE STERILE ZVI + KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
Sterile ZVI + KB-1™	14-Dec-04	0	baseline water ¹	598	<1	<1	<1	<1	--
			baseline water ²	600	<1	<1	<1	<1	--
			Average Conc. (mg/L)	599	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.4E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.478	ND	ND	ND	ND	0.478
	14-Dec-04	0.04	Sterile ZVI + KB-1™ -1	490	<1	<1	<1	<1	--
			Sterile ZVI + KB-1™ -2	377	<1	<1	<1	<1	--
			Sterile ZVI + KB-1™ -3	595	<1	<1	<1	<1	--
			Average Conc. (mg/L)	487	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.1E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.389	ND	ND	ND	ND	0.389
	14-Dec-04	0.08	Sterile ZVI + KB-1™ -1	557	1.4	<1	2.2	4.2	--
			Sterile ZVI + KB-1™ -2	659	1.4	<1	2.1	5.8	--
			Sterile ZVI + KB-1™ -3	644	1.4	<1	2.0	4.9	--
			Average Conc. (mg/L)	620	1.4	ND	2.1	5.0	--
			Standard Deviation (mg/L)	5.5E+01	2.1E-02	0.0E+00	1.1E-01	8.0E-01	--
			Average Total (mmoles)	0.494	0.00150	ND	0.0136	0.0494	0.559
	14-Dec-04	0.25	Sterile ZVI + KB-1™ -1	566	3.7	<1	5.1	16	--
			Sterile ZVI + KB-1™ -2	739	3.9	<1	5.4	17	--
			Sterile ZVI + KB-1™ -3	733	3.4	<1	5.3	12	--
			Average Conc. (mg/L)	679	3.7	ND	5.3	15	--
			Standard Deviation (mg/L)	9.8E+01	2.3E-01	0.0E+00	1.8E-01	2.3E+00	--
			Average Total (mmoles)	0.542	0.00390	ND	0.0346	0.149	0.729
	15-Dec-04	1	Sterile ZVI + KB-1™ -1	171	6.6	<0.5	17	32	--
			Sterile ZVI + KB-1™ -2	406	6.7	<0.5	18	32	--
			Sterile ZVI + KB-1™ -3	371	7.1	<0.5	19	32	--
			Average Conc. (mg/L)	316	6.8	ND	18	32	--
			Standard Deviation (mg/L)	1.3E+02	2.7E-01	0.0E+00	1.0E+00	1.5E-01	--
			Average Total (mmoles)	0.252	0.00727	ND	0.120	0.316	0.696
	17-Dec-04	3	Sterile ZVI + KB-1™ -1	50	7.8	0.33	26	23	--
			Sterile ZVI + KB-1™ -2	122	6.3	0.28	25	20	--
			Sterile ZVI + KB-1™ -3	130	6.5	0.27	26	21	--
			Average Conc. (mg/L)	101	6.9	0.29	26	21	--
			Standard Deviation (mg/L)	4.4E+01	7.9E-01	3.1E-02	8.0E-01	1.1E+00	--
			Average Total (mmoles)	0.0802	0.00731	5.12E-04	0.168	0.212	0.469
	21-Dec-04	7	Sterile ZVI + KB-1™ -1	6.7	6.8	0.23	39	7.6	--
			Sterile ZVI + KB-1™ -2	17	6.9	0.25	38	7.9	--
			Sterile ZVI + KB-1™ -3	18	6.9	0.24	40	8.5	--
			Average Conc. (mg/L)	14	6.9	0.24	39	8.0	--
			Standard Deviation (mg/L)	6.2E+00	9.1E-02	1.3E-02	7.5E-01	4.6E-01	--
			Average Total (mmoles)	0.0110	0.00730	4.20E-04	0.256	0.0792	0.354
	29-Dec-04	15	Sterile ZVI + KB-1™ -1	1.0	5.0	0.41	24	3.2	--
			Sterile ZVI + KB-1™ -2	2.4	5.4	0.33	30	4.0	--
			Sterile ZVI + KB-1™ -3	1.1	5.4	0.39	40	6.3	--
			Average Conc. (mg/L)	1.5	5.2	0.38	31	4.5	--
			Standard Deviation (mg/L)	7.7E-01	2.3E-01	4.3E-02	7.9E+00	1.6E+00	--
			Average Total (mmoles)	0.00118	0.00556	6.62E-04	0.207	0.0445	0.259

TABLE 10: SUMMARY OF VOC DATA FROM DISSOLVED PHASE STERILE ZVI + KB-1TM
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	07-Jan-05	24	Sterile ZVI + KB-1 TM -1	1.1	3.7	0.27	23	2.6	--
			Sterile ZVI + KB-1 TM -2	1.8	4.1	0.23	22	2.5	--
			Sterile ZVI + KB-1 TM -3	2.0	3.9	0.26	31	4.4	--
			Average Conc. (mg/L)	1.6	3.9	0.25	25	3.2	--
			Standard Deviation (mg/L)	4.9E-01	1.8E-01	2.2E-02	5.0E+00	1.0E+00	--
			Average Total (mmoles)	0.00130	0.00417	4.39E-04	0.167	0.0312	0.204
	12-Jan-05	29	Sterile ZVI + KB-1 TM -1	3.3	3.5	<0.2	27	3.7	--
			Sterile ZVI + KB-1 TM -2	2.5	3.4	0.27	16	1.6	--
			Sterile ZVI + KB-1 TM -3	3.8	3.4	<0.2	26	3.6	--
			Average Conc. (mg/L)	3.2	3.4	0.09	23	3.0	--
			Standard Deviation (mg/L)	6.9E-01	7.1E-02	1.6E-01	6.2E+00	1.2E+00	--
			Average Total (mmoles)	0.00255	0.00361	1.59E-04	0.149	0.0297	0.185
	07-Feb-05	55	Comment	buffered all replicates to a target of pH 7					
	09-Feb-05	57	Sterile ZVI + KB-1 TM -1	2.5	1.0	<0.2	18	2.2	--
			Sterile ZVI + KB-1 TM -2	1.7	1.4	0.18	11	1.1	--
			Sterile ZVI + KB-1 TM -3	1.9	0.8	0.17	16	1.9	--
			Average Conc. (mg/L)	2.0	1.0	0.12	15	1.7	--
			Standard Deviation (mg/L)	4.1E-01	3.1E-01	1.0E-01	3.6E+00	5.7E-01	--
			Average Total (mmoles)	0.00160	0.00110	2.09E-04	0.0978	0.0168	0.118
	15-Feb-05	63	Sterile ZVI + KB-1 TM -1	1.6	0.63	<0.2	13	1.5	--
			Sterile ZVI + KB-1 TM -2	1.5	0.94	<0.2	10	1.0	--
			Sterile ZVI + KB-1 TM -3	0.4	0.51	<0.2	13	1.5	--
			Average Conc. (mg/L)	1.2	0.70	ND	12	1.3	--
			Standard Deviation (mg/L)	6.5E-01	2.2E-01	0.0E+00	1.8E+00	3.0E-01	--
			Average Total (mmoles)	9.32E-04	7.40E-04	ND	0.0775	0.0129	0.092
	15-Feb-05	63	Comment	buffered all replicates to a target of pH 7 and re-bioaugmented with KB-1TM					
	23-Feb-05	71	Sterile ZVI + KB-1 TM -1	<0.2	0.46	<0.2	10	1.2	--
			Sterile ZVI + KB-1 TM -2	<0.2	0.68	<0.2	9.3	0.94	--
			Sterile ZVI + KB-1 TM -3	<0.2	0.63	<0.2	11	1.3	--
			Average Conc. (mg/L)	ND	0.59	ND	10	1.1	--
			Standard Deviation (mg/L)	0.0E+00	1.2E-01	0.0E+00	8.2E-01	1.8E-01	--
			Average Total (mmoles)	ND	6.26E-04	ND	0.0670	0.0113	0.079

Notes:

¹ baseline samples taken from AC replicate 2 after being open for 23 seconds

² baseline samples taken from AC replicate 3 after being open for 23 seconds

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

TCE - trichloroethylene

VC - vinyl chloride

VOC -volatile organic carbon

ZVI - zero valent iron

-- - not analyzed/not applicable

> - compound exceeded calibration limits of the instrument

TABLE 11: SUMMARY OF VOC DATA FROM DISSOLVED PHASE EZVI + KB-1TM
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
EZVI + KB-1 TM	14-Dec-04	0	baseline water ¹	560	<1	<1	<1	<1	--
			baseline water ²	573	<1	<1	<1	<1	--
			Average Conc. (mg/L)	567	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	9.2E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.452	ND	ND	ND	ND	0.452
	14-Dec-04	0.04	EZVI +KB-1 TM -1	474	<1	<1	<1	<1	--
			EZVI +KB-1 TM -2	526	<1	<1	<1	<1	--
			EZVI +KB-1 TM -3	465	<1	<1	<1	<1	--
			Average Conc. (mg/L)	488	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.3E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.389	ND	ND	ND	ND	0.389
	14-Dec-04	0.08	7	393	<1	<1	<1	<1	--
			8	249	<1	<1	<1	<1	--
			9	226	<1	<1	<1	<1	--
			Average Conc. (mg/L)	289	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	9.0E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Amount (mmol)	0.231	ND	ND	ND	ND	0.231
	14-Dec-04	0.25	7	199	<1	<1	<1	<1	--
			8	139	<1	<1	<1	<1	--
			9	118	<1	<1	<1	<1	--
			Average Conc. (mg/L)	152	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	4.2E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Amount (mmol)	0.121	ND	ND	ND	ND	0.121
	15-Dec-04	1	7	64.8	0.73	<0.5	0.65	0.70	--
			8	114	0.79	<0.5	0.69	0.72	--
			9	60.8	0.80	<0.5	0.87	0.91	--
			Average Conc. (mg/L)	80	0.77	ND	0.73	0.78	--
			Standard Deviation (mg/L)	3.0E+01	3.9E-02	0.0E+00	1.2E-01	1.2E-01	--
			Average Amount (mmol)	0.0637	8.19E-04	ND	0.00483	0.00770	0.0771
	17-Dec-04	3	7	56.6	1.7	<0.2	2.3	1.9	--
			8	60.2	1.6	<0.2	2.5	2.0	--
			9	56.1	1.7	<0.2	2.6	2.3	--
			Average Conc. (mg/L)	58	1.7	ND	2.5	2.1	--
			Standard Deviation (mg/L)	2.2E+00	7.3E-02	0.0E+00	1.3E-01	1.9E-01	--
			Average Amount (mmol)	0.0460	0.00181	ND	0.0162	0.0206	0.0846
	21-Dec-04	7	7	47.3	3.3	<0.2	8.8	4.2	--
			8	68.3	3.2	<0.2	10	4.7	--
			9	58.4	4.0	<0.2	12	5.6	--
			Average Conc. (mg/L)	58	3.5	ND	10	4.8	--
			Standard Deviation (mg/L)	1.0E+01	4.2E-01	0.0E+00	1.8E+00	7.1E-01	--
			Average Amount (mmol)	0.0463	0.00370	ND	0.0677	0.0478	0.166
	29-Dec-04	15	7	34.1	6.6	<0.2	31	6.1	--
			8	65.1	6.5	0.226	29	6.4	--
			9	38.8	6.3	0.238	29	5.8	--
			Average Conc. (mg/L)	46	6.5	0.15466667	30	6.1	--
			Standard Deviation (mg/L)	1.7E+01	1.6E-01	1.3E-01	1.1E+00	3.2E-01	--
			Average Amount (mmol)	0.0367	0.00688	2.71E-04	0.195	0.0604	0.299
	07-Jan-05	24	7	20.1	6.9	0.3	28	4.2	--
			8	33.6	24	0.28	30	4.9	--
			9	33.7	18	0.298	33	5.6	--
			Average Conc. (mg/L)	29	17	0.29266667	30	4.9	--
			Standard Deviation (mg/L)	7.8E+00	8.9E+00	1.1E-02	2.6E+00	7.1E-01	--
			Average Amount (mmol)	0.0232	0.0176	5.13E-04	0.199	0.0488	0.289

TABLE 11: SUMMARY OF VOC DATA FROM DISSOLVED PHASE EZVI + KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	12-Jan-05	29	7	5.19	38	<0.2	28	3.8	--
			8	7.22	26	<0.2	34	5.0	--
			9	6.80	16	<0.2	36	5.3	--
			Average Conc. (mg/L)	6.4	26	ND	33	4.7	--
			Standard Deviation (mg/L)	1.1E+00	1.1E+01	0.0E+00	4.4E+00	8.1E-01	--
			Average Amount (mmol)	0.00511	0.0282	ND	0.215	0.0467	0.295
	19-Jan-05	36	7	4.77	6.6	<0.2	24	3.5	--
			8	9.16	6.8	0.248	33	5.2	--
			9	17.8	9.6	0.276	39	6.7	--
			Average Conc. (mg/L)	11	7.7	0.175	32	5.1	--
			Standard Deviation (mg/L)	6.6E+00	1.7E+00	1.5E-01	7.1E+00	1.6E+00	--
			Average Amount (mmol)	0.00843	0.00814	3.06E-04	0.211	0.0508	0.279
	26-Jan-05	43	7	6.90	8.9	<0.2	21	3.1	--
			8	5.22	6.8	<0.2	33	5.0	--
			9	4.18	6.7	<0.2	35	5.4	--
			Average Conc. (mg/L)	5.4	7.5	ND	30	4.5	--
			Standard Deviation (mg/L)	1.4E+00	1.3E+00	0.0E+00	7.3E+00	1.3E+00	--
			Average Amount (mmol)	0.00433	0.00797	ND	0.195	0.0445	0.252
	02-Feb-05	50	7	3.18	7.6	0.272	26	4.2	--
			8	2.89	5.8	0.552	31	4.6	--
			9	2.48	6.6	1.018	38	5.9	--
			Average Conc. (mg/L)	2.9	6.6	0.614	32	4.9	--
			Standard Deviation (mg/L)	3.5E-01	9.1E-01	3.8E-01	6.2E+00	8.9E-01	--
			Average Amount (mmol)	0.00227	0.00707	0.00108	0.209	0.0488	0.268
	07-Feb-05	55	Comment	buffered all replicates to a target of pH 7					
	09-Feb-05	57	7	3.03	8.4	0.23	17	2.2	--
			8	2.40	7.0	0.21	32	5.3	--
			9	1.82	7.9	0.22	28	4.2	--
			Average Conc. (mg/L)	2.4	7.8	0.219	26	3.9	--
			Standard Deviation (mg/L)	6.0E-01	7.0E-01	1.2E-02	8.0E+00	1.6E+00	--
			Average Amount (mmol)	0.00193	0.00827	3.83E-04	0.168	0.0388	0.217
	15-Feb-05	63	7	0.38	5.0	<0.2	16	2.1	--
			8	0.34	4.5	<0.2	25	4.0	--
			9	0.44	5.0	<0.2	24	3.5	--
			Average Conc. (mg/L)	0.39	4.8	ND	22	3.2	--
			Standard Deviation (mg/L)	4.8E-02	3.3E-01	0.0E+00	4.7E+00	9.9E-01	--
			Average Amount (mmol)	3.08E-04	0.00515	ND	0.143	0.0319	0.180
	15-Feb-05	63	Comment	buffered all replicates to a target of pH 7 and re-bioaugmented with KB-1™ culture					
	23-Feb-05	71	7	1.35	4.6	<0.2	14	2.0	--
			8	0.94	3.8	<0.2	17	2.6	--
			9	0.90	4.4	<0.2	19	2.8	--
			Average Conc. (mg/L)	1	4.3	ND	17	2.5	--
			Standard Deviation (mg/L)	2.5E-01	4.0E-01	0.0E+00	2.6E+00	4.4E-01	--
			Average Amount (mmol)	8.48E-04	0.00455	ND	0.110	0.0243	0.139
	01-Mar-05	77	7	<0.2	4.2	<0.2	16.9	2.3	--
			8	<0.2	3.2	<0.2	16.3	2.4	--
			9	<0.2	4.1	<0.2	19.6	2.9	--
			Average Conc. (mg/L)	ND	3.8	ND	18	2.5	--
			Standard Deviation (mg/L)	0.0E+00	5.8E-01	0.0E+00	1.8E+00	3.6E-01	--
			Average Amount (mmol)	ND	0.00407	ND	0.116	0.0250	0.145

TABLE 11: SUMMARY OF VOC DATA FROM DISSOLVED PHASE EZVI + KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	09-Mar-05	85	7	<0.2	4.3	<0.2	15.3	2.3	--
			8	<0.2	3.3	<0.2	16.0	2.5	--
			9	<0.2	4.4	<0.2	19.9	2.9	--
			Average Conc. (mg/L)	ND	4.0	ND	17	2.6	--
			Standard Deviation (mg/L)	0.0E+00	6.3E-01	0.0E+00	2.5E+00	3.3E-01	--
			Average Amount (mmol)	ND	0.00426	ND	0.112	0.0255	0.142
	16-Mar-05	92	7	<0.2	3.7	<0.2	15.4	2.3	--
			8	<0.2	2.5	<0.2	13.9	2.0	--
			9	<0.2	3.4	<0.2	18.3	2.7	--
			Average Conc. (mg/L)	ND	3.2	ND	16	2.4	--
			Standard Deviation (mg/L)	0.0E+00	0.6	0.0E+00	2.3E+00	3.5E-01	--
			Average Amount (mmol)	ND	0.0	ND	0.104	0.0234	0.131
	23-Mar-05	99	7	<0.2	2.9	<0.2	16.4	2.3	--
			8	<0.2	2.0	<0.2	14.6	2.1	--
			9	<0.2	2.9	<0.2	17.7	2.5	--
			Average Conc. (mg/L)	ND	2.6	ND	16	2.3	--
			Standard Deviation (mg/L)	0.0E+00	5.3E-01	0.0E+00	1.6E+00	2.0E-01	--
			Average Amount (mmol)	ND	0.00277	ND	0.107	0.0227	0.132
	01-Apr-05	108	7	<0.2	2.3	<0.2	13.5	2.0	--
			8	<0.2	1.7	<0.2	14.7	2.3	--
			9	<0.2	2.6	<0.2	17.6	2.6	--
			Average Conc. (mg/L)	ND	2.2	ND	15	2.3	--
			Standard Deviation (mg/L)	0.0E+00	4.6E-01	0.0E+00	2.1E+00	2.9E-01	--
			Average Amount (mmol)	ND	0.00234	ND	0.101	0.0226	0.125
	27-Apr-05	134	Comment	Re-spiked all three replicates with 1000 mg/L TCE					
	27-Apr-05	134	7	79	2.0	<1	15	3.7	--
			8	126	1.0	<1	15	5.0	--
			9	72	2.2	<1	22	4.6	--
			Average Conc. (mg/L)	92	1.7	ND	17	4.4	--
			Standard Deviation (mg/L)	2.9E+01	6.4E-01	0.0E+00	4.0E+00	7.0E-01	--
			Average Amount (mmol)	0.0981	0.00183	ND	0.113	0.0438	0.256
	29-Apr-05	136	7	77	2.6	<1	15.8	8.5	--
			8	93	1.5	<1	14.8	15	--
			9	36	1.7	<1	6.51	3.8	--
			Average Conc. (mg/L)	69	1.9	ND	12	9.1	--
			Standard Deviation (mg/L)	2.9E+01	5.6E-01	0.0E+00	5.1E+00	5.6E+00	--
			Average Amount (mmol)	0.0730	0.00205	ND	0.0814	0.0899	0.246
	04-May-05	141	7	107	4.5	<1	20	13	--
			8	270	5.7	<1	22	23	--
			9	234	7.0	<1	20	14	--
			Average Conc. (mg/L)	204	5.7	ND	21	17	--
			Standard Deviation (mg/L)	8.6E+01	1.2E+00	0.0E+00	8.5E-01	5.5E+00	--
			Average Amount (mmol)	0.217	0.00608	ND	0.136	0.166	0.524
	11-May-05	148	7	47	5.2	<1	21	11	--
			8	81	5.3	<1	22	19	--
			9	92	6.4	<1	22	12	--
			Average Conc. (mg/L)	73	5.6	ND	22	14	--
			Standard Deviation (mg/L)	2.4E+01	7.0E-01	0.0E+00	7.0E-01	4.1E+00	--
			Average Amount (mmol)	0.0779	0.00598	ND	0.144	0.139	0.367

TABLE 11: SUMMARY OF VOC DATA FROM DISSOLVED PHASE EZVI + KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	20-May-05	157	7	247	16	<1	36	18	--
			8	43	7.1	<1	29	26	--
			9	125	11	<1	29	14	--
			Average Conc. (mg/L)	138	11.2	ND	31	19	--
			Standard Deviation (mg/L)	1.0E+02	4.3E+00	0.0E+00	4.2E+00	6.0E+00	--
			Average Amount (mmol)	0.147	0.0119	ND	0.207	0.192	0.558
	26-May-05	163	7	30	7.7	0.10	26	8.8	--
			8	70	7.6	0.0	27	16	--
			9	62	8.5	0.0	21	7.8	--
			Average Conc. (mg/L)	54	7.9	ND	25	11	--
			Standard Deviation (mg/L)	2.2E+01	4.7E-01	5.8E-02	3.4E+00	4.6E+00	--
			Average Amount (mmol)	0.0574	0.00842	ND	0.162	0.109	0.336
	01-Jun-05	169	7	32	6.7	<1	24	15	--
			8	44	7.5	<1	25	16	--
			9	70	10	<1	23	8.2	--
			Average Conc. (mg/L)	49	8.1	ND	24	13	--
			Standard Deviation (mg/L)	2.0E+01	1.8E+00	0.0E+00	8.6E-01	4.2E+00	--
			Average Amount (mmol)	0.0516	0.00863	ND	0.158	0.130	0.348
	08-Jun-05	176	7	71	11	<1	31	8.7	--
			8	180	14	<1	30	17	--
			9	41	8.6	<1	26	7.9	--
			Average Conc. (mg/L)	98	11	ND	29	11	--
			Standard Deviation (mg/L)	7.3E+01	3.0E+00	0.0E+00	2.8E+00	4.8E+00	--
			Average Amount (mmol)	0.104	0.0119	ND	0.190	0.110	0.416
	15-Jun-05	183	Comment	Re-spiked all three replicates with 1000 mg/L TCE					
	15-Jun-05	183	7	334	12	<1	29	8.0	--
			8	63	6.3	<1	26	14	--
			9	72	8.0	<1	26	6.8	--
			Average Conc. (mg/L)	156	8.7	ND	27	10	--
			Standard Deviation (mg/L)	1.5E+02	2.9E+00	0.0E+00	1.8E+00	4.1E+00	--
			Average Amount (mmol)	0.166	0.00926	ND	0.178	0.0965	0.450
	22-Jun-05	190	7	79	8.9	<1	29	8.4	--
			8	141	9.0	<1	32	18	--
			9	565	14	<1	24	8.0	--
			Average Conc. (mg/L)	261	10.6	ND	29	11	--
			Standard Deviation (mg/L)	2.6E+02	2.8E+00	0.0E+00	4.2E+00	5.4E+00	--
			Average Amount (mmol)	0.278	0.0112	ND	0.188	0.113	0.590

TABLE 11: SUMMARY OF VOC DATA FROM DISSOLVED PHASE EZVI + KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	29-Jun-05	197	7	208	12	<1	29	8.0	--
			8	146	9.5	<1	24	15	--
			9	101	10	<1	25	8.2	--
			Average Conc. (mg/L)	152	10.4	ND	26	10	--
			Standard Deviation (mg/L)	5.4E+01	1.3E+00	0.0E+00	2.5E+00	3.9E+00	--
			Average Amount (mmol)	0.161	0.0111	ND	0.173	0.102	0.447
	08-Jul-05	206	7	NA	NA	NA	NA	NA	--
			8	106	8.6	<1	26	15	--
			9	79	10	<1	27	9.5	--
			Average Conc. (mg/L)	92	9	ND	27	12	--
			Standard Deviation (mg/L)	1.9E+01	1.2E+00	0.0E+00	5.9E-01	4.1E+00	--
			Average Amount (mmol)	0.0983	0.0101	ND	0.175	0.123	0.407

Notes:

¹ baseline samples taken from SC replicate 3 after being open for 1 minute and 10 seconds

² baseline samples taken from AC replicate 1 after being open for 1 minute and 10 seconds

EZVI - emulsified zero valent iron

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

TCE - trichlorethylene

VC - vinyl chloride

VOC -volatile organic carbon

-- - not analyzed/not applicable

> - compound exceeded calibration limits of the instrument

TABLE 12: SUMMARY OF VOC DATA FROM DISSOLVED PHASE STERILE EZVI+ KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
Sterile EZVI + KB-1™	14-Dec-04	0	baseline water ¹	560	<1	<1	<1	<1	--
			baseline water ²	573	<1	<1	<1	<1	--
			Average Conc. (mg/L)	567	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	9.2E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.452	ND	ND	ND	ND	0.452
	14-Dec-04	0.04	Sterile EZVI+KB-1™ -1	194	<1	<1	<1	<1	--
			Sterile EZVI+KB-1™ -2	492	<1	<1	<1	<1	--
			Sterile EZVI+KB-1™ -3	549	<1	<1	<1	<1	--
			Average Conc. (mg/L)	412	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.9E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.328	ND	ND	ND	ND	0.328
	14-Dec-04	0.08	Sterile EZVI+KB-1™ -1	253	<1	<1	<1	<1	--
			Sterile EZVI+KB-1™ -2	205	<1	<1	<1	<1	--
			Sterile EZVI+KB-1™ -3	238	<1	<1	<1	<1	--
			Average Conc. (mg/L)	232	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	2.5E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.185	ND	ND	ND	ND	0.185
	14-Dec-04	0.25	Sterile EZVI+KB-1™ -1	247	<1	<1	<1	<1	--
			Sterile EZVI+KB-1™ -2	70	<1	<1	<1	<1	--
			Sterile EZVI+KB-1™ -3	99	<1	<1	<1	<1	--
			Average Conc. (mg/L)	138	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	9.5E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.110	ND	ND	ND	ND	0.110
	15-Dec-04	1	Sterile EZVI+KB-1™ -1	86	0.58	<0.5	0.68	0.77	--
			Sterile EZVI+KB-1™ -2	54	0.68	<0.5	0.98	0.79	--
			Sterile EZVI+KB-1™ -3	82	0.70	<0.5	0.93	0.64	--
			Average Conc. (mg/L)	74	0.65	ND	0.86	0.73	--
			Standard Deviation (mg/L)	1.7E+01	6.6E-02	0.0E+00	1.6E-01	8.0E-02	--
			Average Total (mmoles)	0.0591	6.91E-04	ND	0.00566	0.00725	0.073
	17-Dec-04	3	Sterile EZVI+KB-1™ -1	48	1.2	<0.2	2.5	2.4	--
			Sterile EZVI+KB-1™ -2	58	1.6	<0.2	2.6	2.8	--
			Sterile EZVI+KB-1™ -3	51	1.7	<0.2	3.3	2.7	--
			Average Conc. (mg/L)	52	1.5	ND	2.8	2.6	--
			Standard Deviation (mg/L)	5.0E+00	2.5E-01	0.0E+00	4.2E-01	1.8E-01	--
			Average Total (mmoles)	0.0418	0.00159	ND	0.0184	0.0262	0.088
	21-Dec-04	7	Sterile EZVI+KB-1™ -1	61	3.1	<0.2	9.4	5.1	--
			Sterile EZVI+KB-1™ -2	44	3.4	<0.2	13	6.4	--
			Sterile EZVI+KB-1™ -3	67	4.0	<0.2	12	5.6	--
			Average Conc. (mg/L)	57	3.5	ND	11	5.7	--
			Standard Deviation (mg/L)	1.2E+01	4.9E-01	0.0E+00	1.9E+00	6.8E-01	--
			Average Total (mmoles)	0.0457	0.00372	ND	0.0750	0.0565	0.181
	29-Dec-04	15	Sterile EZVI+KB-1™ -1	42	5.1	0.22	25	5.7	--
			Sterile EZVI+KB-1™ -2	50	6.4	<0.2	31	5.9	--
			Sterile EZVI+KB-1™ -3	30	5.8	0.25	30	6.1	--
			Average Conc. (mg/L)	41	5.8	0.16	29	5.9	--
			Standard Deviation (mg/L)	1.0E+01	6.3E-01	1.4E-01	3.7E+00	2.0E-01	--
			Average Total (mmoles)	0.0324	0.00613	2.76E-04	0.190	0.0585	0.287

TABLE 12: SUMMARY OF VOC DATA FROM DISSOLVED PHASE STERILE EZVI+ KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	07-Jan-05	24	Sterile EZVI+KB-1™ -1	NA	NA	NA	NA	NA	--
			Sterile EZVI+KB-1™ -2	16	6.7	0.224	29	4.2	--
			Sterile EZVI+KB-1™ -3	30	7.9	0.298	37	6.2	--
			Average Conc. (mg/L)	23	7.3	0.261	33	5.2	--
			Standard Deviation (mg/L)	1.0E+01	9.0E-01	5.2E-02	5.9E+00	1.4E+00	--
	12-Jan-05	29	Average Total (mmoles)	0.0184	0.00777	4.57E-04	0.218	0.0517	0.296
			Sterile EZVI+KB-1™ -1	9.0	6.2	<0.2	33	4.6	--
			Sterile EZVI+KB-1™ -2	5.6	4.3	0.25	15	1.9	--
			Sterile EZVI+KB-1™ -3	10	6.9	<0.2	35	5.7	--
			Average Conc. (mg/L)	8.2	5.8	0.08	28	4.1	--
			Standard Deviation (mg/L)	2.3E+00	1.4E+00	1.4E-01	1.1E+01	2.0E+00	--
			Average Total (mmoles)	0.00654	0.00615	1.44E-04	0.183	0.0404	0.236
	19-Jan-05	36	Sterile EZVI+KB-1™ -1	5	5.4	0.22	25	3.3	--
			Sterile EZVI+KB-1™ -2	13	8.0	0.29	25	3.7	--
			Sterile EZVI+KB-1™ -3	17	10.9	0.35	34	6.7	--
			Average Conc. (mg/L)	12	8.1	0.29	28	4.5	--
			Standard Deviation (mg/L)	5.7E+00	2.8E+00	6.2E-02	5.4E+00	1.8E+00	--
			Average Total (mmoles)	0.00918	0.00863	5.06E-04	0.184	0.0450	0.247
	26-Jan-05	43	Sterile EZVI+KB-1™ -1	4.4	5.7	<0.2	23.8	3.2	--
			Sterile EZVI+KB-1™ -2	4.9	6.6	<0.2	24.9	3.6	--
			Sterile EZVI+KB-1™ -3	Bad sample					--
			Average Conc. (mg/L)	4.7	6.1	ND	24.4	3.4	--
			Standard Deviation (mg/L)	3.7E-01	6.6E-01	0.0E+00	8.0E-01	3.1E-01	--
			Average Total (mmoles)	0.00372	0.00653	ND	0.160	0.0334	0.204
	02-Feb-05	50	Sterile EZVI+KB-1™ -1	5.1	5.5	0.20	22.0	2.6	--
			Sterile EZVI+KB-1™ -2	3.4	5.7	0.23	22.6	2.7	--
			Sterile EZVI+KB-1™ -3	2.6	6.3	1.0	33.2	5.0	--
			Average Conc. (mg/L)	3.7	5.8	0.48	25.9	3.5	--
			Standard Deviation (mg/L)	1.3E+00	4.4E-01	4.6E-01	6.3E+00	1.3E+00	--
			Average Total (mmoles)	0.00296	0.00621	8.41E-04	0.171	0.0342	0.215
	06-Feb-05	54	Comment	buffered all replicates to a target of pH 7					
	09-Feb-05	57	Sterile EZVI+KB-1™ -1	3.8	6.3	0.21	20	2.7	--
			Sterile EZVI+KB-1™ -2	2.2	6.5	0.22	27	4.0	--
			Sterile EZVI+KB-1™ -3	0.84	6.6	0.20	23	3.2	--
			Average Conc. (mg/L)	2.3	6.5	0.21	23	3.3	--
			Standard Deviation (mg/L)	1.5E+00	1.7E-01	1.2E-02	3.2E+00	6.5E-01	--
			Average Total (mmoles)	0.00181	0.00687	0.000368	0.154	0.0328	0.196
	15-Feb-05	63	Sterile EZVI+KB-1™ -1	1.5	6.7	<0.2	17	2.2	--
			Sterile EZVI+KB-1™ -2	0.89	6.2	<0.2	19	2.4	--
			Sterile EZVI+KB-1™ -3	0.47	5.9	<0.2	21	2.8	--
			Average Conc. (mg/L)	1.0	6.2	ND	19	2.5	--
			Standard Deviation (mg/L)	5.4E-01	4.3E-01	0.0E+00	1.8E+00	3.3E-01	--
			Average Total (mmoles)	7.70E-04	0.00664	ND	0.126	0.0244	0.158

TABLE 12: SUMMARY OF VOC DATA FROM DISSOLVED PHASE STERILE EZVI+ KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	15-Feb-05	63	Comment	buffered all replicates to a target of pH 7 and re-bioaugmented with KB-1™ culture					
	23-Feb-05	71	Sterile EZVI+KB-1™ -1	0.35	5.1	<0.2	17	2.1	--
			Sterile EZVI+KB-1™ -2	--	--	--	--	--	--
			Sterile EZVI+KB-1™ -3	0.76	5.3	<0.2	21	3.1	--
			Average Conc. (mg/L)	0.56	5.2	ND	19	2.6	--
			Standard Deviation (mg/L)	2.9E-01	1.0E-01	0.0E+00	2.8E+00	7.2E-01	--
			Average Total (mmoles)	4.45E-04	0.00554	ND	0.122	0.0256	0.154
	01-Mar-05	77	Sterile EZVI+KB-1™ -1	<0.2	5.2	<0.2	18	2.3	--
			Sterile EZVI+KB-1™ -2	<0.2	4.8	<0.2	23	3.3	--
			Sterile EZVI+KB-1™ -3	<0.2	4.3	<0.2	20	2.8	--
			Average Conc. (mg/L)	0	4.8	ND	21	2.8	--
			Standard Deviation (mg/L)	0.0E+00	4.7E-01	0.0E+00	2.9E+00	4.9E-01	--
			Average Total (mmoles)	0	0.00506	ND	0.135	0.0275	0.168

Notes:

¹ baseline samples taken from SC replicate 3 after being open for 1 minute and 10 seconds

² baseline samples taken from AC replicate 1 after being open for 1 minute and 10 seconds

EZVI - emulsified zero valent iron

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

TCE - trichlorethylene

VC - vinyl chloride

VOC -volatile organic carbon

-- - not analyzed/not applicable

> - compound exceeded calibration limits of the instrument

TABLE 13: SUMMARY OF CHLORIDE, LACTATE, PH AND DOC RESULTS FOR DNAPL PHASE TREATMENTS SIREM
EZVI Laboratory Treatability Study

Treatment	Date	Day	Replicate	Lactate	Chloride	pH (paper)	pH (meter)	DOC
				mg/L	mg/L			mg/L
Active Control	1-Feb-05	0	AC-1	2.8	50	--	6.90	6.8
			AC-2	--	--	--	--	--
			AC-3	--	--	--	--	--
			Average Conc.	2.8	50	--	--	--
	9-Feb-05	8	AC-1	4.5	54	--	--	--
			AC-2	2.3	26	--	--	--
			AC-3	1.9	26	--	6.73	6.3
			Average Conc.	2.9	36	--	--	--
	16-Feb-05	15	AC-2	--	--	--	7.05	--
	23-Feb-05	22	AC-2	--	--	--	7.05	--
	1-Mar-05	28	AC-3	--	--	--	6.85	--
	6-Apr-05	64	AC-1	4.4	60	--	--	8.7
			AC-2	3.5	31	--	--	--
			AC-3	3.2	29	--	--	--
			Average Conc.	3.7	40	--	--	--
EZVI + KB-1™	1-Feb-05	0	EZVI+KB-1™-1	3.3	46	--	6.94	11.2
			EZVI+KB-1™-2	--	--	--	--	--
			EZVI+KB-1™-3	--	--	--	--	--
			Average Conc.	3.3	46	--	--	--
	9-Feb-05	8	EZVI+KB-1™-1	4.0	73	--	--	--
			EZVI+KB-1™-2	3.8	73	--	--	--
			EZVI+KB-1™-3	3.8	74	--	8.39	14.1
			Average Conc.	3.9	74	--	--	--
	16-Feb-05	15	EZVI+KB-1™-2	--	--	--	8.37	--
	23-Feb-05	22	EZVI+KB-1™-2	--	--	--	8.58	--
	1-Mar-05	28	EZVI+KB-1™-3	--	--	--	8.95	--
	9-Mar-05	36	EZVI+KB-1™-2	--	--	--	8.83	--
	6-Apr-05	64	EZVI+KB-1™-1	8.2	305	--	--	15.3
			EZVI+KB-1™-2	6.6	212	--	--	--
			EZVI+KB-1™-3	6.7	237	--	--	--
			Average Conc.	7.2	251	--	--	--
	25-Jul-05	174	EZVI+KB-1™-1	--	--	--	--	--
			EZVI+KB-1™-2	--	--	--	--	--
			EZVI+KB-1™-3	8.5	5727	--	--	--
			Average Conc.	8.5	5727	--	--	--

TABLE 13: SUMMARY OF CHLORIDE, LACTATE, PH AND DOC RESULTS FOR DNAPL PHASE TREATMENTS SIREM
EZVI Laboratory Treatability Study

Treatment	Date	Day	Replicate	Lactate	Chloride	pH (paper)	pH (meter)	DOC
				mg/L	mg/L			mg/L
Emulsion+KB-1TM	1-Feb-05	0	Emulsion+KB-1 TM -1	3.1	43	--	7.27	11.4
			Emulsion+KB-1 TM -2	--	--	--	--	--
			Emulsion+KB-1 TM -3	--	--	--	--	--
			Average Conc.	3.1	43	--	--	--
	9-Feb-05	8	Emulsion+KB-1 TM -1	4.1	48	--	--	--
			Emulsion+KB-1 TM -2	2.1	48	--	--	--
			Emulsion+KB-1 TM -3	4.8	52	--	7.70	16.4
			Average Conc.	3.7	49	--	--	--
	16-Feb-05	15	Emulsion+KB-1 TM -1	--	--	--	8.90	--
	23-Feb-05	22	Emulsion+KB-1 TM -2	--	--	--	7.13	--
	1-Mar-05	28	Emulsion+KB-1 TM -3	--	--	--	7.35	--
	6-Apr-05	64	Emulsion+KB-1 TM -1	139	54	--	--	48.4
			Emulsion+KB-1 TM -2	195	61	--	--	--
			Emulsion+KB-1 TM -3	141	63	--	--	--
			Average Conc.	158	59	--	--	--
ZVI + KB-1TM	1-Feb-05	0	ZVI+KB-1 TM -1	2.8	68	--	6.90	12.3
			ZVI+KB-1 TM -2	--	--	--	--	--
			ZVI+KB-1 TM -3	--	--	--	--	--
			Average Conc.	2.8	68	--	--	--
	9-Feb-05	8	ZVI+KB-1 TM -1	4.0	1905	--	--	--
			ZVI+KB-1 TM -2	4.6	2108	--	--	--
			ZVI+KB-1 TM -3	4.1	1900	--	6.28	5.4
			Average Conc.	4.2	1971	--	--	--
	16-Feb-05	15	ZVI+KB-1 TM -1	--	--	--	6.76	--
	23-Feb-05	22	ZVI+KB-1 TM -2	--	--	--	6.52	--
	1-Mar-05	28	ZVI+KB-1 TM -3	--	--	--	6.52	--
	9-Mar-05	36	ZVI+KB-1 TM -2	--	--	--	6.84	--
	6-Apr-05	64	ZVI+KB-1 TM -1	7.8	2601	--	--	9.7
			ZVI+KB-1 TM -2	6.1	2701	--	--	--
			ZVI+KB-1 TM -3	5.5	2648	--	--	--
			Average Conc.	6.5	2650	--	--	--

Notes:

AC - active control

DOC - dissolved organic carbon

mg/L - milligrams per liter

ND - non detect

-- - not analyzed/not applicable

ZVI - zero valent iron

EZVI - emulsified zero-valent iron

TABLE 14: SUMMARY OF VOC DATA FOR DNAPL PHASE ACTIVE CONTROL
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					Total Ethenes and Ethane mmol/bottle
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	
Active Control	01-Feb-05	0	baseline water ¹	873	<1	<1	<1	<1	--
			Average Conc. (mg/L)	873	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	NA	NA	NA	NA	NA	--
			Average Total (mmoles)	1.49	ND	ND	ND	ND	1.49
	01-Feb-05	0.04	AC-1	854	<1	<1	<1	<1	--
			AC-2	1006	<1	<1	<1	<1	--
			AC-3	907	<1	<1	<1	<1	--
			Average Conc. (mg/L)	922	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	7.7E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	1.57	ND	ND	ND	ND	1.57
	02-Feb-05	1	AC-1	808	<1	<1	<1	<1	--
			AC-2	909	<1	<1	<1	<1	--
			AC-3	904	<1	<1	<1	<1	--
			Average Conc. (mg/L)	874	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	5.7E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	1.49	ND	ND	ND	ND	1.49
	04-Feb-05	3	AC-1	1021	<1	<1	<1	<1	--
			AC-2	1226	<1	<1	<1	<1	--
			AC-3	1068	<1	<1	<1	<1	--
			Average Conc. (mg/L)	1105	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	5.7E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	1.88	ND	ND	ND	ND	1.88
	09-Feb-05	8	AC-1	971	<1	<1	<1	<1	--
			AC-2	1149	<1	<1	<1	<1	--
			AC-3	1151	<1	<1	<1	<1	--
			Average Conc. (mg/L)	1090	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.0E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	1.86	ND	ND	ND	ND	1.86
	16-Feb-05	15	AC-1	1082	<1	<1	<1	<1	--
			AC-2	1138	<1	<1	<1	<1	--
			AC-3	1182	<1	<1	<1	<1	--
			Average Conc. (mg/L)	1134	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	5.0E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	1.93	ND	ND	ND	ND	1.93
	23-Feb-05	22	AC-1	976	<1	<1	<1	<1	--
			AC-2	1106	<1	<1	<1	<1	--
			AC-3	1402	<1	<1	<1	<1	--
			Average Conc. (mg/L)	1161	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	2.2E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	1.98	ND	ND	ND	ND	1.98
	01-Mar-05	28	AC-1	762	<1	<1	<1	<1	--
			AC-2	853	<1	<1	<1	<1	--
			AC-3	NA	NA	NA	NA	NA	--
			Average Conc. (mg/L)	807	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	6.4E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	1.38	ND	ND	ND	ND	1.38

Notes:

¹baseline samples taken from replicate #1

AC - active control

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

TCE - trichloroethylene

VC - vinyl chloride

VOC -volatile organic carbon

-- - not analyzed/not applicable

TABLE 15: SUMMARY OF VOC DATA FOR DNAPL PHASE OIL EMULSION +KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
Emulsion+KB-1™	01-Feb-05	0	baseline water ¹	1066	<1	<1	<1	<1	--
			(mg/L)	1066	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	NA	NA	NA	NA	NA	--
			Average Total (mmoles)	1.41	ND	ND	ND	ND	1.41
	01-Feb-05	0.04	Emulsion+KB-1™-1	336	<1	<1	<1	<1	--
			Emulsion+KB-1™-2	502	<1	<1	<1	<1	--
			Emulsion+KB-1™-3	617	<1	<1	<1	<1	--
			(mg/L)	485	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.4E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.642	ND	ND	ND	ND	0.642
	01-Feb-05	0.08	Emulsion+KB-1™-1	>1000	<1	<1	<1	<1	--
			Emulsion+KB-1™-2	330	<1	<1	<1	<1	--
			Emulsion+KB-1™-3	1110	<1	<1	<1	<1	--
			(mg/L)	480	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	5.7E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.636	ND	ND	ND	ND	0.636
	01-Feb-05	0.25	Emulsion+KB-1™-1	>1000	<1	<1	<1	<1	--
			Emulsion+KB-1™-2	>1000	<1	<1	<1	<1	--
			Emulsion+KB-1™-3	692	<1	<1	<1	<1	--
			(mg/L)	231	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	4.0E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.305	ND	ND	ND	ND	0.305
	02-Feb-05	1	Emulsion+KB-1™-1	>1000	<1	<1	<1	<1	--
			Emulsion+KB-1™-2	>1000	<1	<1	<1	<1	--
			Emulsion+KB-1™-3	>1000	<1	<1	<1	<1	--
			(mg/L)	1000	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	1.32	ND	ND	ND	ND	1.32
	04-Feb-05	3	Emulsion+KB-1™-1	327	<1	<1	<1	<1	--
			Emulsion+KB-1™-2	430	<1	<1	<1	<1	--
			Emulsion+KB-1™-3	365	<1	<1	<1	<1	--
			(mg/L)	374	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	5.2E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.495	ND	ND	ND	ND	0.495
	09-Feb-05	8	Emulsion+KB-1™-1	>1000	<1	<1	<1	<1	--
			Emulsion+KB-1™-2	786	<1	<1	<1	<1	--
			Emulsion+KB-1™-3	403	<1	<1	<1	<1	--
			(mg/L)	396	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.9E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.525	ND	ND	ND	ND	0.525
	16-Feb-05	15	Emulsion+KB-1™-1	293	<1	<1	<1	<1	--
			Emulsion+KB-1™-2	799	<1	<1	<1	<1	--
			Emulsion+KB-1™-3	348	<1	<1	<1	<1	--
			(mg/L)	480	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	2.8E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.636	ND	ND	ND	ND	0.636

TABLE 15: SUMMARY OF VOC DATA FOR DNAPL PHASE OIL EMULSION +KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	23-Feb-05	22	Emulsion+KB-1™-1	250	<1	<1	<1	<1	--
			Emulsion+KB-1™-2	232	<1	<1	<1	<1	--
			Emulsion+KB-1™-3	214	<1	<1	<1	<1	--
			(mg/L)	232	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	1.8E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.307	ND	ND	ND	ND	0.307
	01-Mar-05	28	Emulsion+KB-1™-1	>1000	<1	<1	<1	<1	--
			Emulsion+KB-1™-2	715	<1	<1	<1	<1	--
			Emulsion+KB-1™-3	390	<1	<1	<1	<1	--
			(mg/L)	553	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	3.6E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.732	ND	ND	ND	ND	0.732

Notes:

¹baseline samples taken from replicate #1 before amendments were added

AC - active control

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

TCE - trichlorethylene

VC - vinyl chloride

VOC -volatile organic carbon

-- - not analyzed/not applicable

> - compound exceeded calibration limits of the instrument

TABLE 16: SUMMARY OF VOC DATA FOR DNAPL PHASE ZVI +KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
ZVI + KB-1™	01-Feb-05	0	baseline water ¹	991	<1	<1	<1	<1	--
			Average Conc. (mg/L)	991	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	NA	NA	NA	NA	NA	--
			Average Total (mmoles)	1.69	ND	ND	ND	ND	1.69
	01-Feb-05	0.04	ZVI+KB-1™-1	1180	5.6	<1	<1	16	--
			ZVI+KB-1™-2	1102	5.6	<1	<1	28	--
			ZVI+KB-1™-3	1085	5.6	<1	<1	15	--
			Average Conc. (mg/L)	1122	5.6	ND	ND	20	--
			Standard Deviation (mg/L)	5.1E+01	1.2E-02	0.0E+00	0.0E+00	7.2E+00	--
			Average Total (mmoles)	1.91	0.0125	ND	ND	0.782	2.71
	01-Feb-05	0.08	ZVI+KB-1™-1	1060	7.0	<1	3.4	31	--
			ZVI+KB-1™-2	1021	7.1	<1	3.2	27	--
			ZVI+KB-1™-3	1054	6.8	<1	3.1	27	--
			Average Conc. (mg/L)	1045	7.0	ND	3.2	28	--
			Standard Deviation (mg/L)	2.1E+01	1.5E-01	0.0E+00	1.6E-01	2.3E+00	--
			Average Total (mmoles)	1.78	0.0155	ND	0.0715	1.13	3.00
	01-Feb-05	0.25	ZVI+KB-1™-1	1142	12	<1	11	97	--
			ZVI+KB-1™-2	1084	12	<1	10	78	--
			ZVI+KB-1™-3	1467	11	<1	9.4	76	--
			Average Conc. (mg/L)	1231	12	ND	10	84	--
			Standard Deviation (mg/L)	2.1E+02	4.8E-01	0.0E+00	9.4E-01	1.2E+01	--
			Average Total (mmoles)	2.10	0.0260	ND	0.228	3.328	5.68
	02-Feb-05	1	ZVI+KB-1™-1	>1000	9.0	<1	10	>100	--
			ZVI+KB-1™-2	>1000	9.8	<1	14	>100	--
			ZVI+KB-1™-3	>1000	9.3	<1	10	>100	--
			Average Conc. (mg/L)	1000	9.3	ND	12	100	--
			Standard Deviation (mg/L)	0.0E+00	4.0E-01	0.0E+00	2.1E+00	0.0E+00	--
			Average Total (mmoles)	1.70	0.0207	ND	0.259	3.977	5.96
	04-Feb-05	3	ZVI+KB-1™-1	863	14	<1	16	122	--
			ZVI+KB-1™-2	565	10	<1	8.8	62	--
			ZVI+KB-1™-3	1181	16	<1	15	117	--
			Average Conc. (mg/L)	870	13	ND	13	100	--
			Standard Deviation (mg/L)	3.1E+02	3.4E+00	0.0E+00	3.7E+00	3.3E+01	--
			Average Total (mmoles)	1.48	0.0299	ND	0.292	3.99	5.79
	09-Feb-05	8	ZVI+KB-1™-1	848	16	<1	14	94	--
			ZVI+KB-1™-2	923	17	<1	16	82	--
			ZVI+KB-1™-3	1045	18	<1	19	95	--
			Average Conc. (mg/L)	939	17	ND	16	90	--
			Standard Deviation (mg/L)	9.9E+01	1.2E+00	0.0E+00	2.5E+00	6.8E+00	--
			Average Total (mmoles)	1.60	0.0383	ND	0.362	3.59	5.59
	16-Feb-05	15	ZVI+KB-1™-1	1304	20	<1	12	74	--
			ZVI+KB-1™-2	1137	20	<1	17	66	--
			ZVI+KB-1™-3	1234	20	<1	17	70	--
			Average Conc. (mg/L)	1225	20	ND	15	70	--
			Standard Deviation (mg/L)	8.4E+01	1.3E-01	0.0E+00	2.6E+00	4.3E+00	--
			Average Total (mmoles)	2.09	0.0446	ND	0.346	2.778	5.26
	23-Feb-05	22	ZVI+KB-1™-1	631	18	<1	13	69	--
			ZVI+KB-1™-2	763	20	<1	16	57	--
			ZVI+KB-1™-3	779	20	<1	16	59	--
			Average Conc. (mg/L)	725	20	ND	15	62	--
			Standard Deviation (mg/L)	8.1E+01	1.2E+00	0.0E+00	1.7E+00	6.1E+00	--
			Average Total (mmoles)	1.24	0.0437	ND	0.342	2.45	4.07
	01-Mar-05	28	ZVI+KB-1™-1	765	18	<1	12	54	--
			ZVI+KB-1™-2	1019	22	<1	15	44	--
			ZVI+KB-1™-3	1003	21	<1	16	46	--
			Average Conc. (mg/L)	929	21	ND	14	48	--
			Standard Deviation (mg/L)	1.4E+02	2.4E+00	0.0E+00	1.8E+00	4.9E+00	--
			Average Total (mmoles)	1.58	0.0456	ND	0.322	1.910	3.86

TABLE 16: SUMMARY OF VOC DATA FOR DNAPL PHASE ZVI +KB-1TM
EZVI Laboratory Treatability Study

SIREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
	09-Mar-05	36	ZVI+KB-1 TM -1	mg/L 1035	mg/L 22	mg/L <1	mg/L 14	mg/L 49	mmol/bottle --
			ZVI+KB-1 TM -2	1036	24	<1	16	37	--
			ZVI+KB-1 TM -3	1041	24	<1	16	38	--
			Average Conc. (mg/L)	1037	23	ND	15	41	--
			Standard Deviation (mg/L)	3.5E+00	1.1E+00	0.0E+00	1.2E+00	6.9E+00	--
			Average Total (mmoles)	1.77	0.0511	ND	0.341	1.64	3.80
	16-Mar-05	43	ZVI+KB-1 TM -1	877	23	<1	16	47	--
			ZVI+KB-1 TM -2	1079	28	<1	16	32	--
			ZVI+KB-1 TM -3	916	23	<1	17	33	--
			Average Conc. (mg/L)	958	25	ND	16	38	--
			Standard Deviation (mg/L)	1.1E+02	3.1E+00	0.0E+00	2.6E-01	8.6E+00	--
			Average Total (mmoles)	1.63	0.0553	ND	0.368	1.494	3.55
	23-Mar-05	50	ZVI+KB-1 TM -1	1078	26	<1	16	41	--
			ZVI+KB-1 TM -2	1109	28	<1	18	28	--
			ZVI+KB-1 TM -3	1164	28	<1	20	32	--
			Average Conc. (mg/L)	1117	28	ND	18	34	--
			Standard Deviation (mg/L)	4.3E+01	1.2E+00	0.0E+00	1.9E+00	6.3E+00	--
			Average Total (mmoles)	1.90	0.0617	ND	0.401	1.35	3.71
	30-Mar-05	57	ZVI+KB-1 TM -1	817	24	1.1	19	29	--
			ZVI+KB-1 TM -2	671	21	<1	12	14	--
			ZVI+KB-1 TM -3	1040	28	1.0	18	24	--
			Average Conc. (mg/L)	843	24	0.72	16	22	--
			Standard Deviation (mg/L)	1.9E+02	3.9E+00	6.2E-01	3.7E+00	7.5E+00	--
			Average Total (mmoles)	1.44	0.0540	0.00284	0.363	0.894	2.75

Notes:

¹baseline samples taken from replicate #1 before amendments were added

AC - active control

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

TCE - trichlorethylene

VC - vinyl chloride

VOC -volatile organic carbon

ZVI -zero valent iron

-- - not analyzed/not applicable

> - compound exceeded calibration limits of the instrument

TABLE 17: SUMMARY OF VOC DATA FOR DNAPL PHASE EZVI+KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
EZVI + KB-1™	01-Feb-05	0	baseline water ¹	1181	<1	<1	<1	<1	--
			Average Conc. (mg/L)	1181	ND	ND	ND	ND	--
			Standard Deviation (mg/L)	NA	NA	NA	NA	NA	--
			Average Total (mmoles)	1.56	ND	ND	ND	ND	1.56
	01-Feb-05	0.04	EZVI+KB-1™-1	321	2.4	<1	<1	<1	--
			EZVI+KB-1™-2	224	3.3	<1	<1	<1	--
			EZVI+KB-1™-3	550	2.0	<1	<1	<1	--
			Average Conc. (mg/L)	365	2.56	0.00	0.00	0.00	--
			Standard Deviation (mg/L)	1.7E+02	6.5E-01	0.0E+00	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.483	0.00436	ND	ND	ND	0.49
	01-Feb-05	0.08	EZVI+KB-1™-1	369	3.9	1.5	0.20	<1	--
			EZVI+KB-1™-2	236	<1	<1	<1	<1	--
			EZVI+KB-1™-3	441	4.6	<1	<1	<1	--
			Average Conc. (mg/L)	348	2.84	0.51	0.07	0.00	--
			Standard Deviation (mg/L)	1.0E+02	2.5E+00	8.8E-01	1.2E-01	0.0E+00	--
			Average Total (mmoles)	0.461	0.00484	0.00161	0.00138	0	0.47
	01-Feb-05	0.25	EZVI+KB-1™-1	229	2.9	1.0	<1	<1	--
			EZVI+KB-1™-2	254	1.8	1.8	<1	<1	--
			EZVI+KB-1™-3	357	2.4	1.8	<1	<1	--
			Average Conc. (mg/L)	280	2.38	1.52	ND	ND	--
			Standard Deviation (mg/L)	6.8E+01	5.6E-01	4.4E-01	0.0E+00	0.0E+00	--
			Average Total (mmoles)	0.371	0.00406	0.00481	ND	ND	0.38
	02-Feb-05	1	EZVI+KB-1™-1	281	1.1	<0.2	1.6	6.0	--
			EZVI+KB-1™-2	166	1.0	0.4	1.7	6.0	--
			EZVI+KB-1™-3	234	1.4	0.3	2.4	8.0	--
			Average Conc. (mg/L)	227	1.17	0.23	1.89	6.67	--
			Standard Deviation (mg/L)	5.8E+01	2.1E-01	2.1E-01	4.4E-01	1.2E+00	--
			Average Total (mmoles)	0.301	0.00199	7.25E-04	0.0390	0.254	0.60
	04-Feb-05	3	EZVI+KB-1™-1	155	2.3	<1	9.0	13	--
			EZVI+KB-1™-2	221	2.5	<1	8.3	15	--
			EZVI+KB-1™-3	159	2.4	<1	9.0	15	--
			Average Conc. (mg/L)	179	2.4	ND	8.8	15	--
			Standard Deviation (mg/L)	3.7E+01	9.1E-02	0.0E+00	3.7E-01	1.1E+00	--
			Average Total (mmoles)	0.236	0.00410	ND	0.181	0.557	0.98
	09-Feb-05	8	EZVI+KB-1™-1	78	3.8	<1	22	16	--
			EZVI+KB-1™-2	112	4.6	<1	32	24	--
			EZVI+KB-1™-3	127	4.9	<1	32	25	--
			Average Conc. (mg/L)	105	4.4	ND	29	22	--
			Standard Deviation (mg/L)	2.5E+01	6.2E-01	0.0E+00	5.6E+00	4.6E+00	--
			Average Total (mmoles)	0.140	0.00758	ND	0.595	0.828	1.57
	16-Feb-05	15	EZVI+KB-1™-1	97	6.3	<1	46	5.0	--
			EZVI+KB-1™-2	125	6.6	<1	49	6.1	--
			EZVI+KB-1™-3	143	6.4	<1	38	4.9	--
			Average Conc. (mg/L)	121	6.4	ND	44	5.3	--
			Standard Deviation (mg/L)	2.3E+01	1.9E-01	0.0E+00	6.1E+00	6.5E-01	--
			Average Total (mmoles)	0.161	0.0109	ND	0.917	0.202	1.29
	23-Feb-05	22	EZVI+KB-1™-1	89	6.8	<1	52	5.2	--
			EZVI+KB-1™-2	123	7.2	<1	45	4.8	--
			EZVI+KB-1™-3	107	7.5	<1	44	4.9	--
			Average Conc. (mg/L)	106	7.2	ND	47	5.0	--
			Standard Deviation (mg/L)	1.7E+01	3.3E-01	0.0E+00	4.3E+00	1.9E-01	--
			Average Total (mmoles)	0.141	0.0122	ND	0.969	0.189	1.31
	01-Mar-05	28	EZVI+KB-1™-1	70	8.1	<1	62	6.4	--
			EZVI+KB-1™-2	95	7.8	<1	51	5.5	--
			EZVI+KB-1™-3	88	7.4	<1	41	4.3	--
			Average Conc. (mg/L)	84	7.8	ND	51	5.4	--
			Standard Deviation (mg/L)	1.3E+01	3.4E-01	0.0E+00	1.1E+01	1.0E+00	--
			Average Total (mmoles)	0.112	0.0133	ND	1.05	0.205	1.38

TABLE 17: SUMMARY OF VOC DATA FOR DNAPL PHASE EZVI+KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	09-Mar-05	36	EZVI+KB-1™-1	75	10	<1	64	6.7	--
			EZVI+KB-1™-2	93	8.8	<1	51	5.3	--
			EZVI+KB-1™-3	201	11	<1	46	5.2	--
			Average Conc. (mg/L)	123	9.8	ND	54	5.7	--
			Standard Deviation (mg/L)	6.8E+01	9.2E-01	0.0E+00	9.2E+00	8.8E-01	--
			Average Total (mmoles)	0.163	0.0168	ND	1.11	0.218	1.50
	16-Mar-05	43	EZVI+KB-1™-1	26	<1	<1	18	3.6	--
			EZVI+KB-1™-2	232	15	<1	69	8.4	--
			EZVI+KB-1™-3	69	8.6	<1	48	4.9	--
			Average Conc. (mg/L)	109	7.8	ND	45	5.6	--
			Standard Deviation (mg/L)	1.1E+02	7.4E+00	0.0E+00	2.6E+01	2.5E+00	--
			Average Total (mmoles)	0.144	0.0132	ND	0.925	0.215	1.30
	23-Mar-05	50	EZVI+KB-1™-1	65	12	0.59	73	7.4	--
			EZVI+KB-1™-2	102	12	0.62	58	5.3	--
			EZVI+KB-1™-3	86	11	0.61	53	5.5	--
			Average Conc. (mg/L)	85	11	0.61	61	6.1	--
			Standard Deviation (mg/L)	1.8E+01	3.4E-01	1.5E-02	1.0E+01	1.2E+00	--
			Average Total (mmoles)	0.112	0.0196	0.00192	1.26	0.231	1.63
	30-Mar-05	57	EZVI+KB-1™-1	46	11	<1	57	5.6	--
			EZVI+KB-1™-2	98	12	<1	51	5.0	--
			EZVI+KB-1™-3	92	12	<1	47	4.6	--
			Average Conc. (mg/L)	78	12	ND	51	5.1	--
			Standard Deviation (mg/L)	2.8E+01	6.6E-01	0.0E+00	5.0E+00	5.3E-01	--
			Average Total (mmoles)	0.104	0.0202	ND	1.06	0.193	1.38
	06-Apr-05	64	EZVI+KB-1™-1	55	14	<1	79	9.0	--
			EZVI+KB-1™-2	86	13	<1	58	5.7	--
			EZVI+KB-1™-3	82	13	<1	65	6.8	--
			Average Conc. (mg/L)	74	13	ND	67	7.2	--
			Standard Deviation (mg/L)	1.7E+01	6.6E-01	0.0E+00	1.0E+01	1.7E+00	--
			Average Total (mmoles)	0.0982	0.0223	ND	1.39	0.273	1.78
	13-Apr-05	71	EZVI+KB-1™-1	124	18	<1	71	7.6	--
			EZVI+KB-1™-2	83	14	<1	57	5.6	--
			EZVI+KB-1™-3	85	14	<1	53	5.3	--
			Average Conc. (mg/L)	97	15	ND	60	6.2	--
			Standard Deviation (mg/L)	2.3E+01	2.0E+00	0.0E+00	9.5E+00	1.3E+00	--
			Average Total (mmoles)	0.129	0.0261	ND	1.24	0.235	1.63
	20-Apr-05	78	EZVI+KB-1™-1	77	16	<1	67	7.0	--
			EZVI+KB-1™-2	101	17	<1	70	8.0	--
			EZVI+KB-1™-3	112	16	<1	59	6.0	--
			Average Conc. (mg/L)	97	16	ND	65	7.0	--
			Standard Deviation (mg/L)	1.8E+01	3.7E-01	0.0E+00	5.3E+00	9.9E-01	--
			Average Total (mmoles)	0.128	0.0276	ND	1.35	0.267	1.8E+00
	27-Apr-05	85	COMMENT Spiked replicate #3 to a target of 1000 mg/L TCE						
	27-Apr-05	85	EZVI+KB-1™-1	137	21	<1	72	7.0	--
			EZVI+KB-1™-2	74	16	<1	60	6.0	--
			EZVI+KB-1™-3	88	14	<1	43	4.4	--
			Average Conc. (mg/L)	100	17	ND	58	5.8	--
			Standard Deviation (mg/L)	3.3E+01	3.3E+00	0.0E+00	1.5E+01	1.3E+00	--
			Average Total (mmoles)	0.132	0.0289	ND	1.20	0.221	1.58
	29-Apr-05	87	EZVI+KB-1™-1	46	16	<1	74	7.3	--
			EZVI+KB-1™-2	67	15	<1	58	5.5	--
			EZVI+KB-1™-3	88	15	<1	48	4.8	--
			Average Conc. (mg/L)	67	15	ND	60	5.9	--
			Standard Deviation (mg/L)	2.1E+01	4.0E-01	0.0E+00	1.3E+01	1.3E+00	--
			Average Total (mmoles)	0.0884	0.0259	ND	1.24	0.224	1.58

TABLE 17: SUMMARY OF VOC DATA FOR DNAPL PHASE EZVI+KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	04-May-05	92	EZVI+KB-1™-1	47	16	<1	74	7.5	--
			EZVI+KB-1™-2	80	16	<1	61	6.1	--
			EZVI+KB-1™-3	104	16	<1	53	5.6	--
			Average Conc. (mg/L)	77	16	ND	63	6.4	--
			Standard Deviation (mg/L)	2.8E+01	1.4E-01	0.0E+00	1.1E+01	1.0E+00	--
			Average Total (mmoles)	0.102	0.0278	ND	1.29	0.244	1.67
	11-May-05	99	EZVI+KB-1™-1	34	14	<1	65	6.6	--
			EZVI+KB-1™-2	56	14	<1	55	5.5	--
			EZVI+KB-1™-3	79	16	<1	47	5.0	--
			Average Conc. (mg/L)	57	15	ND	56	5.7	--
			Standard Deviation (mg/L)	2.3E+01	1.0E+00	0.0E+00	8.6E+00	7.9E-01	--
			Average Total (mmoles)	0.0749	0.0251	ND	1.15	0.217	1.46
	20-May-05	108	EZVI+KB-1™-1	40	21	<1	71	8.4	--
			EZVI+KB-1™-2	69	17	<1	64	6.2	--
			EZVI+KB-1™-3	96	21	<1	65	6.1	--
			Average Conc. (mg/L)	68	20	ND	67	6.9	--
			Standard Deviation (mg/L)	2.8E+01	2.1E+00	0.0E+00	4.0E+00	1.3E+00	--
			Average Total (mmoles)	0.0904	0.0336	ND	1.37	0.263	1.76
	26-May-05	114	EZVI+KB-1™-1	30	19	<1	65	6.5	--
			EZVI+KB-1™-2	61	19	<1	69	6.7	--
			EZVI+KB-1™-3	79	19	<1	56	5.4	--
			Average Conc. (mg/L)	57	19	ND	63	6.2	--
			Standard Deviation (mg/L)	2.5E+01	3.3E-01	0.0E+00	6.5E+00	7.2E-01	--
			Average Total (mmoles)	0.0749	0.0326	ND	1.31	0.237	1.65
	01-Jun-05	120	EZVI+KB-1™-1	82	19	<1	56	5.6	--
			EZVI+KB-1™-2	72	19	<1	58	5.7	--
			EZVI+KB-1™-3	38	18	<1	61	6.3	--
			Average Conc. (mg/L)	64	19	ND	58	5.8	--
			Standard Deviation (mg/L)	2.3E+01	2.6E-01	0.0E+00	2.2E+00	3.7E-01	--
			Average Total (mmoles)	0.0844	0.0318	ND	1.21	0.223	1.54
	08-Jun-05	127	EZVI+KB-1™-1	32	18	<1	69	7.1	--
			EZVI+KB-1™-2	75	20	<1	69	6.8	--
			EZVI+KB-1™-3	116	20	<1	64	6.3	--
			Average Conc. (mg/L)	74	19	ND	68	6.7	--
			Standard Deviation (mg/L)	4.2E+01	1.2E+00	0.0E+00	3.2E+00	4.1E-01	--
			Average Total (mmoles)	0.0985	0.0332	ND	1.39	0.257	1.78
	15-Jun-05	134	EZVI+KB-1™-1	30	16	<1	53	5.1	--
			EZVI+KB-1™-2	86	20	<1	59	5.6	--
			EZVI+KB-1™-3	83	20	<1	52	4.1	--
			Average Conc. (mg/L)	66	19	ND	55	5.0	--
			Standard Deviation (mg/L)	3.2E+01	2.7E+00	0.0E+00	4.1E+00	7.7E-01	--
			Average Total (mmoles)	0.0874	0.0318	ND	1.13	0.189	1.44
	22-Jun-05	141	EZVI+KB-1™-1	31	21	<1	67	6.6	--
			EZVI+KB-1™-2	64	18	<1	56	4.3	--
			EZVI+KB-1™-3	78	19	<1	59	5.3	--
			Average Conc. (mg/L)	57	19	ND	61	5.4	--
			Standard Deviation (mg/L)	2.4E+01	1.5E+00	0.0E+00	5.8E+00	1.1E+00	--
			Average Total (mmoles)	0.0761	0.0327	ND	1.25	0.205	1.56

TABLE 17: SUMMARY OF VOC DATA FOR DNAPL PHASE EZVI+KB-1™
EZVI Laboratory Treatability Study

SiREM

Treatment	Date	Day	Replicate	Ethenes and Ethane					
				TCE	cis-1,2-DCE	VC	Ethene	Ethane	Total Ethenes and Ethane
				mg/L	mg/L	mg/L	mg/L	mg/L	mmol/bottle
	29-Jun-05	148	EZVI+KB-1™-1	35	28	<1	70	6.8	
			EZVI+KB-1™-2	71	22	<1	62	4.2	
			EZVI+KB-1™-3	98	22	<1	56	3.8	
			Average Conc. (mg/L)	68	24	ND	62	4.9	--
			Standard Deviation (mg/L)	3.2E+01	3.4E+00	0.0E+00	6.8E+00	1.6E+00	--
			Average Total (mmoles)	0.0902	0.0409	ND	1.29	0.188	1.61
	08-Jul-05	157	EZVI+KB-1™-1	29	20	<1	60	5.8	
			EZVI+KB-1™-2	70	47	<1	61	5.1	
			EZVI+KB-1™-3	84	21	<1	54	4.4	
			Average Conc. (mg/L)	61	29	ND	58	5.1	--
			Standard Deviation (mg/L)	2.8E+01	1.5E+01	0.0E+00	3.8E+00	7.1E-01	--
			Average Total (mmoles)	0.0806	0.0496	ND	1.20	0.193	1.53

Notes:

¹baseline samples taken from replicate #1 before amendments were added

EZVI - emulsified zero valent iron

cis-1,2-DCE - cis-1,2-dichloroethene

mg/L - milligrams per liter

mmol/bottle - millimole per bottle

NA - not available

ND - non detect

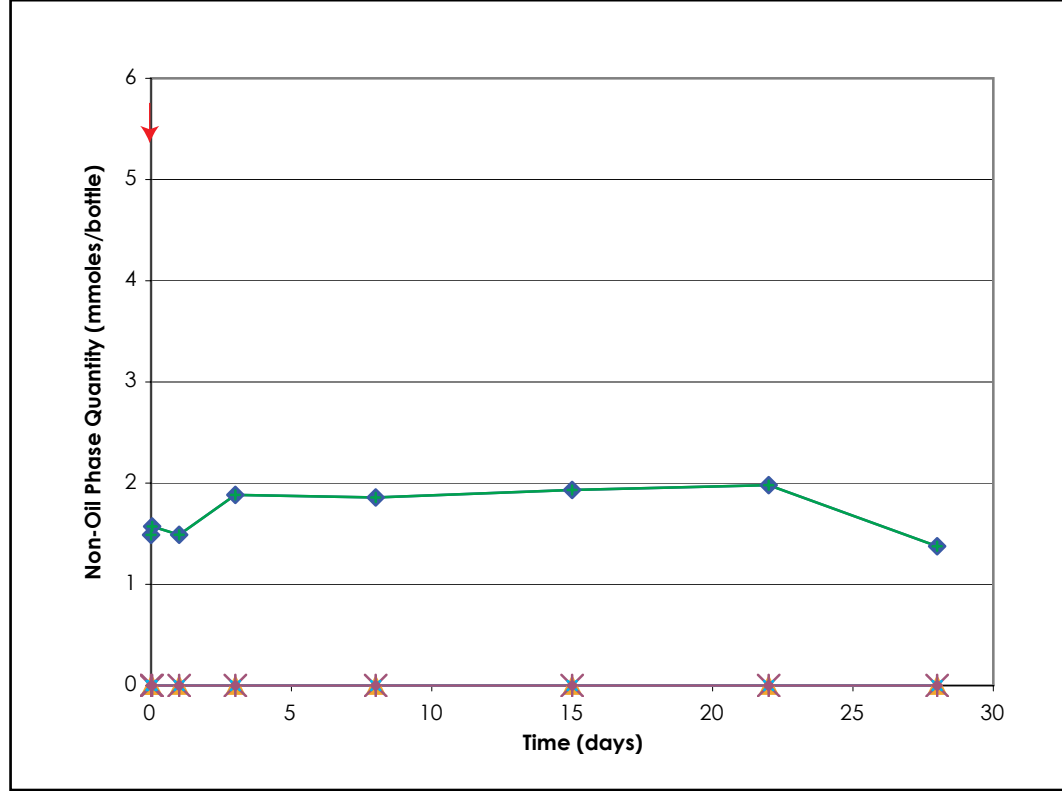
TCE - trichlorethylene

VC - vinyl chloride

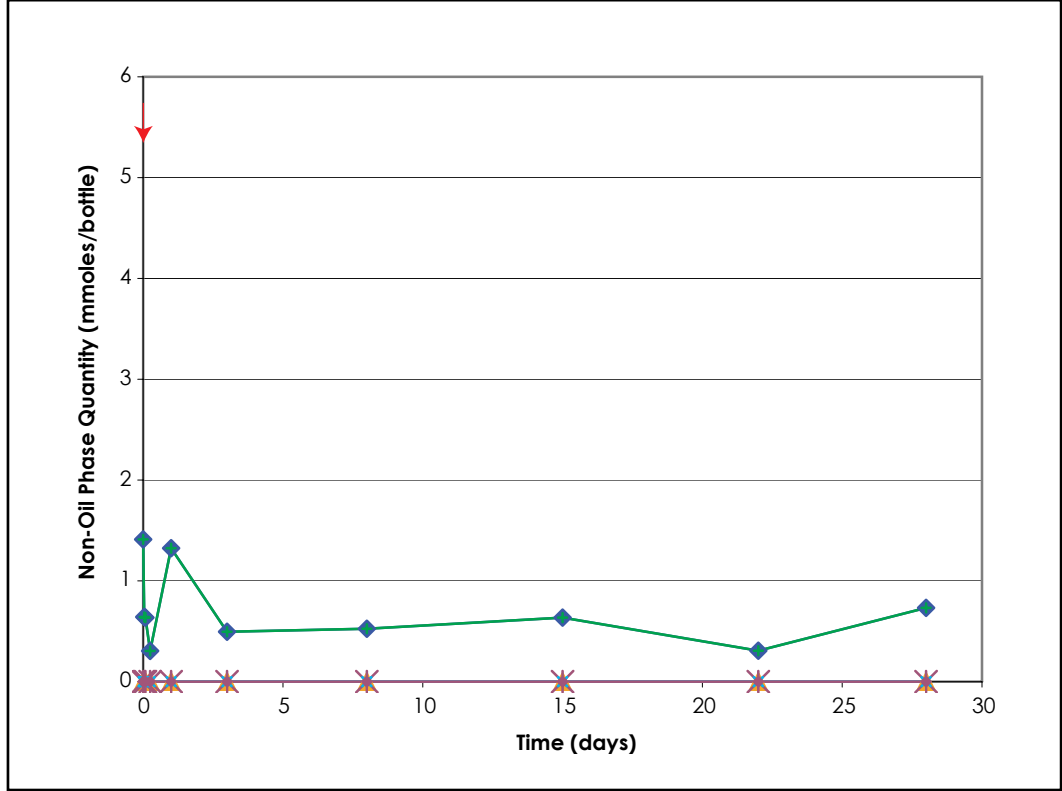
VOC -volatile organic carbon

-- - not analyzed/not applicable

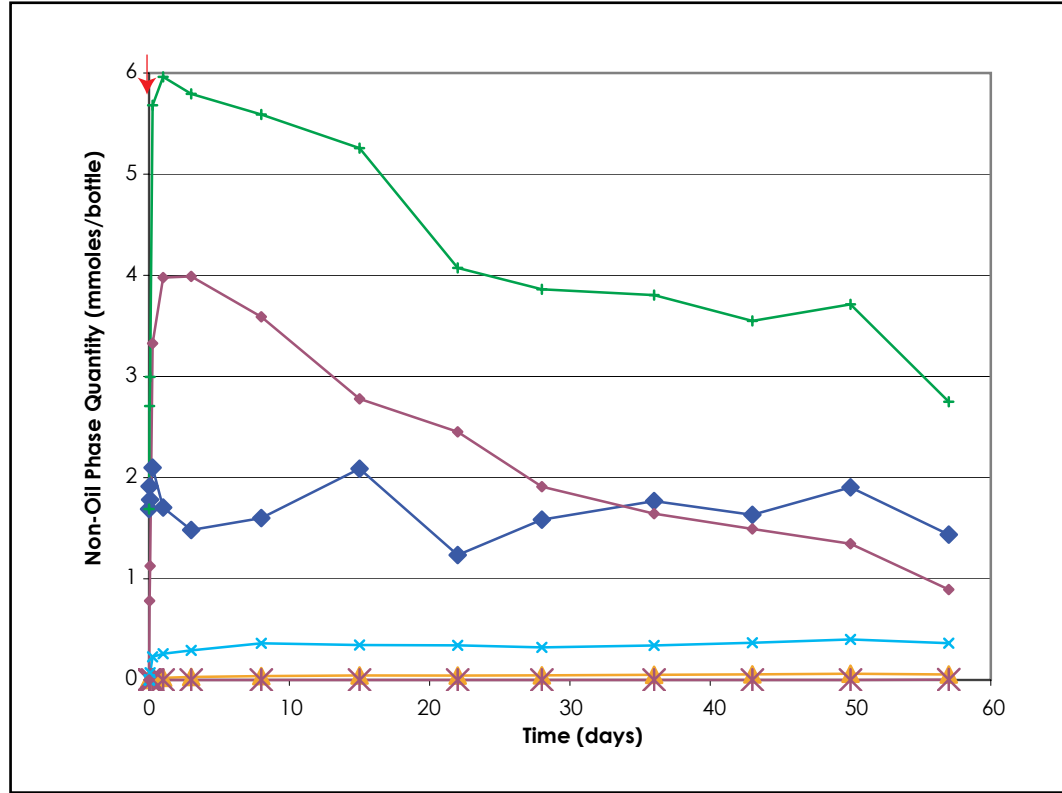
a) Active Control Treatment



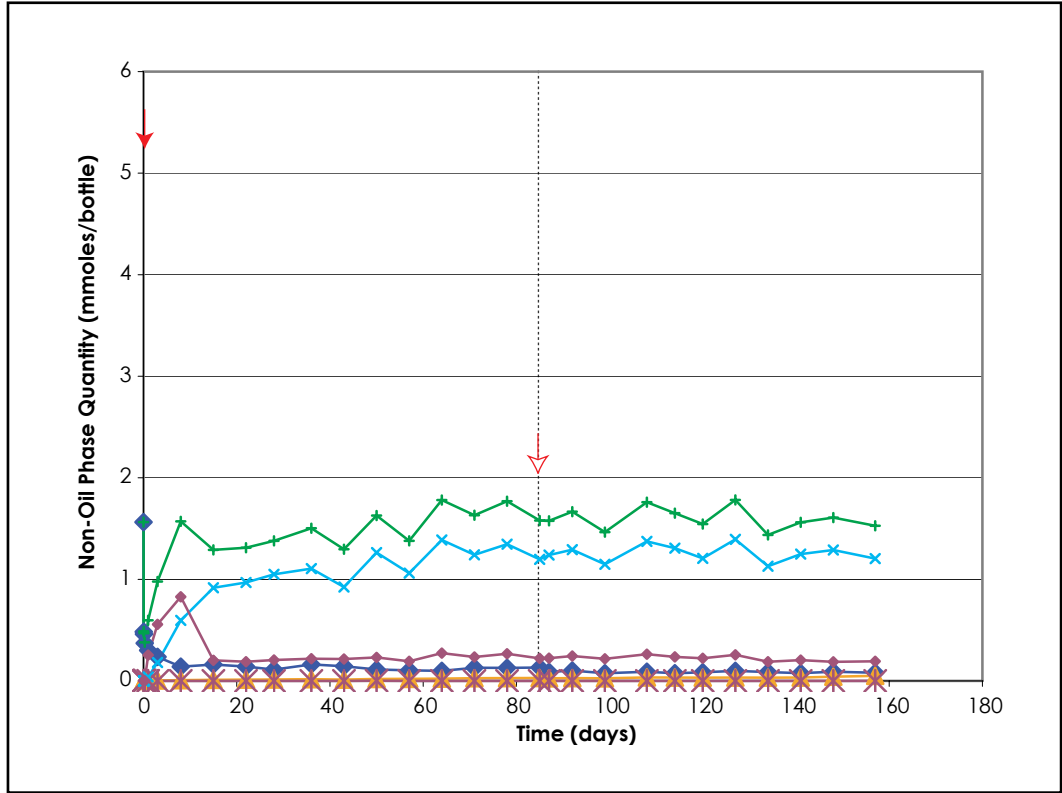
b) Oil Emulsion and KB-1™



c) Zero Valent Iron and KB-1™



d) Emulsified Zero Valent Iron and KB-1™



Legend

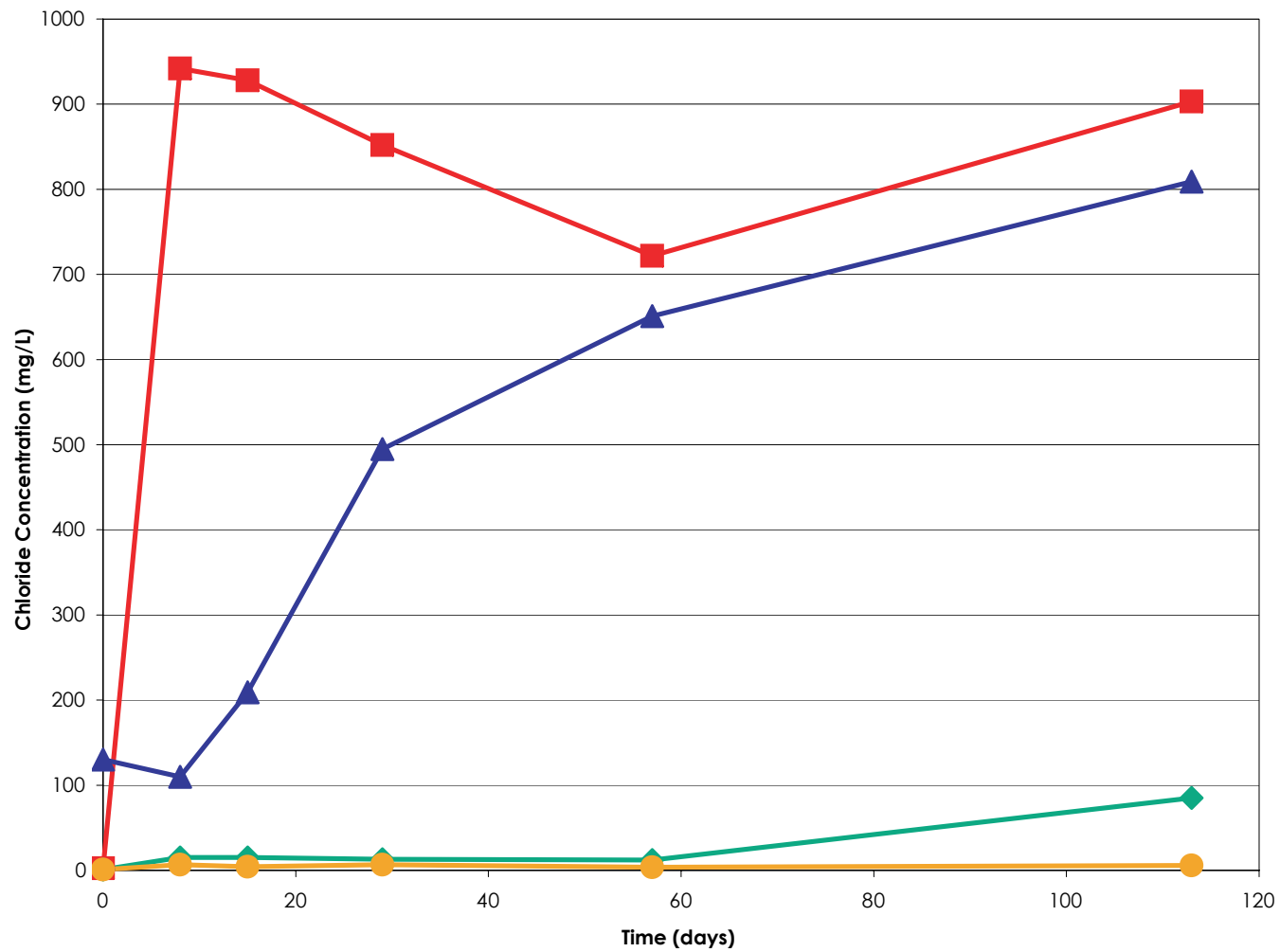
- TCE
- cis-1,2-DCE
- VC
- Ethene
- Ethane
- total ethene+ethane

Notes


- Spiked replicate #3 to a target of 0.8 mmoles TCE (Day 85).
- 16.7 mmoles of TCE added to each test reactor at time zero.
- Aqueous solubility of TCE is approximately 1.67 mmoles per 200 ml of water in each bottle.

Results of TCE DNAPL Treatment Tests
Emulsified Zero-Valent Iron Laboratory
Treatability Study

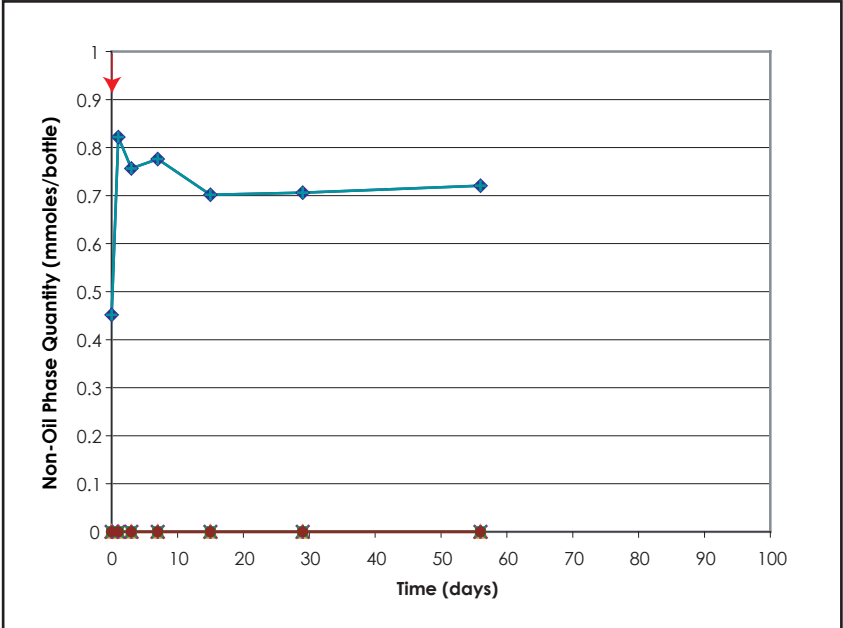
Graph Figure: 0173.d



■ ZVI
▲ EZVI
◆ Oil
● Control

Chloride Concentrations During Dissolved Phase TCE Treatment Tests Emulsified Zero-Valent Iron Laboratory Treatability Studies		
Aug. 2005	Figure: 3	

a) Active Control Treatment



Notes

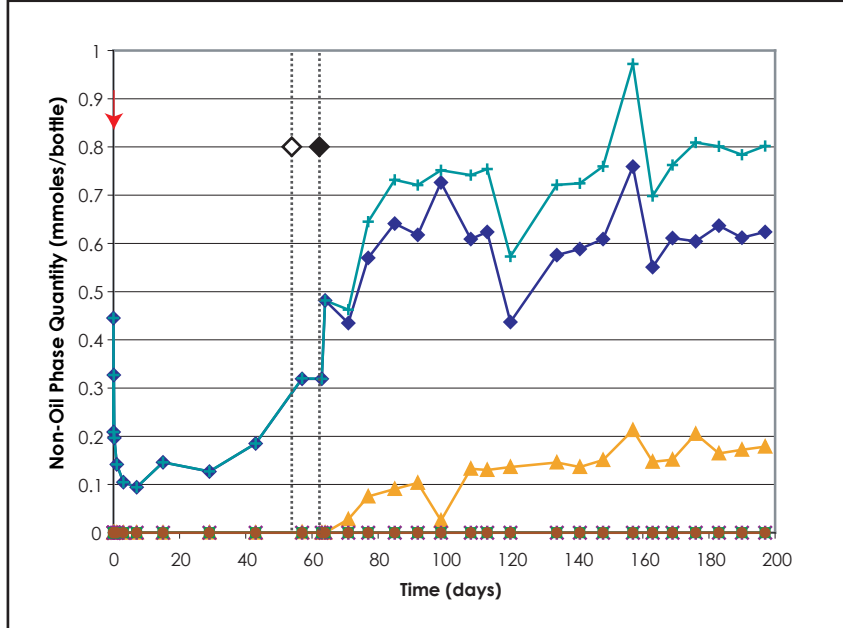
- ◇ Buffered to a target of pH 7 (Day 54).
- ◆ Buffered to a target of pH 7 and re-bioaugmented with KB-1™ (Day 62).

Each test reaction contains 100 ml of water
↓ 0.8 mmoles of TCE added to each test reactor.

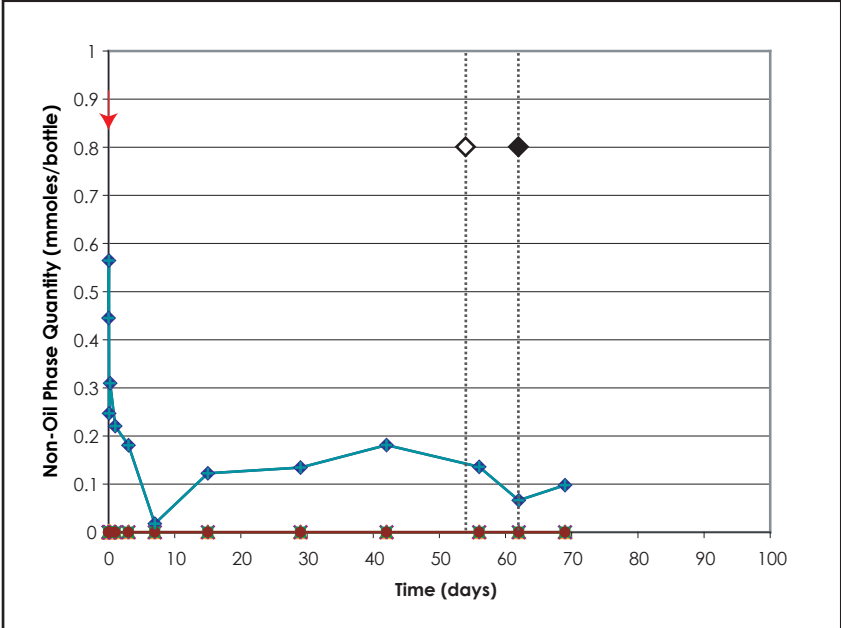
Legend

- ◆ TCE
- ▲ cis-1,2-DCE
- * VC
- Ethene
- Ethane
- + Total Ethene + Ethane

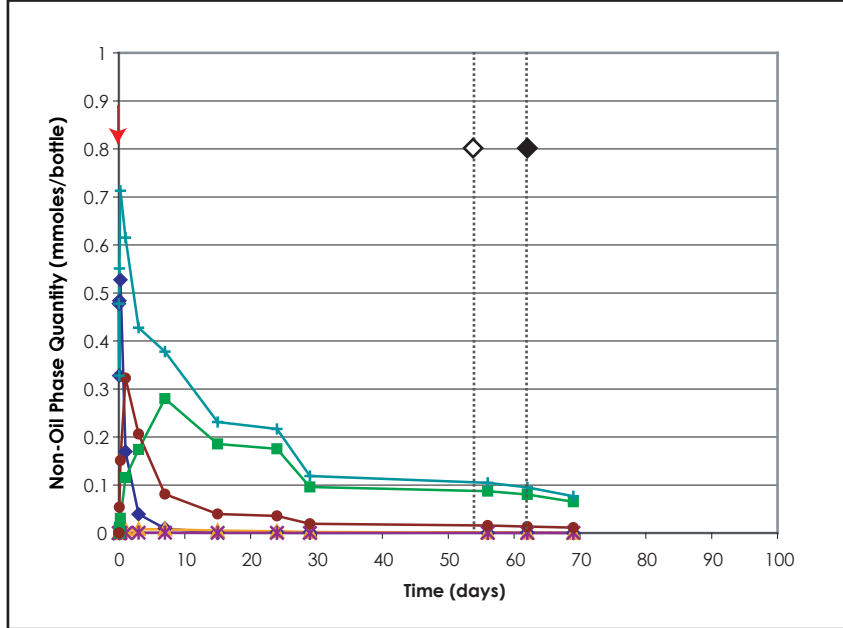
b) Oil Emulsion and KB-1™



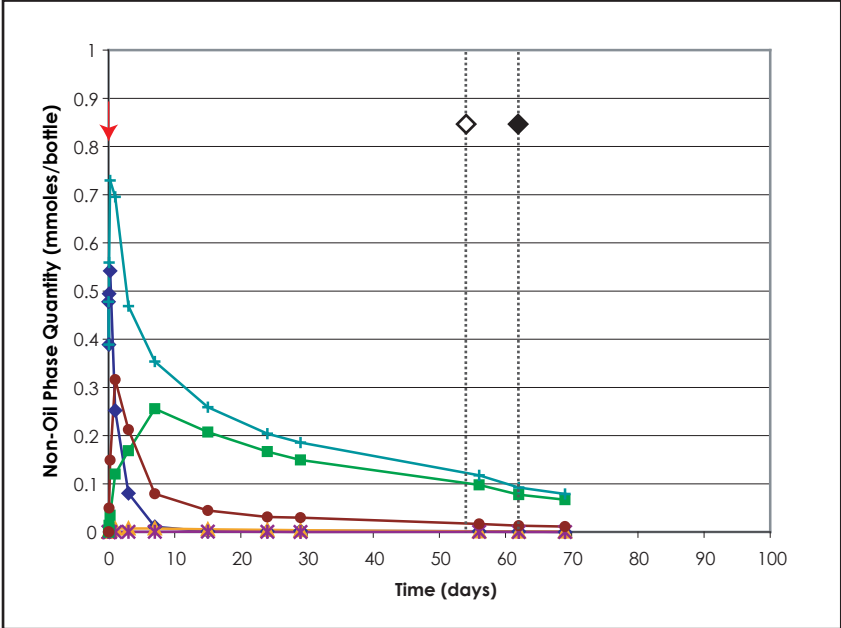
c) Sterile Oil Emulsion and KB-1™



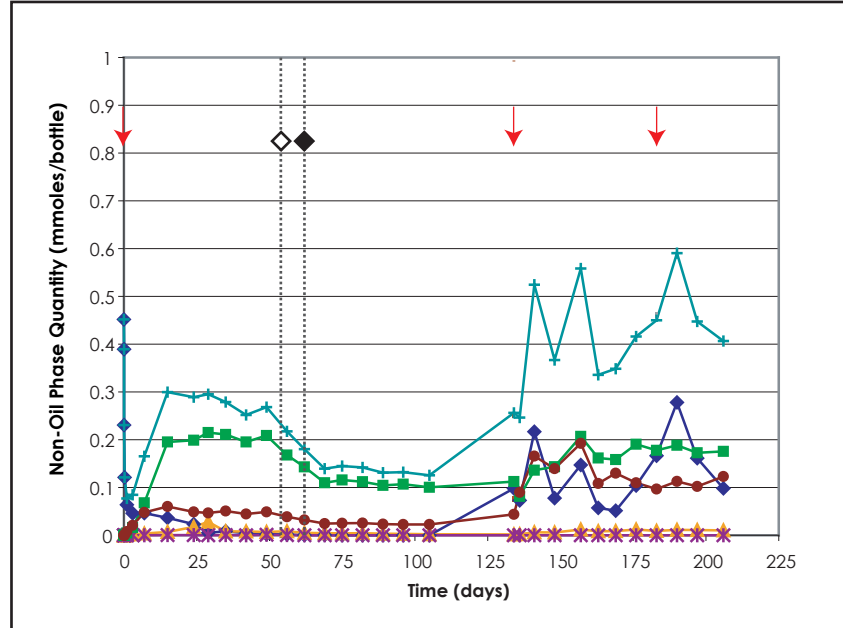
d) Zero Valent Iron and KB-1™



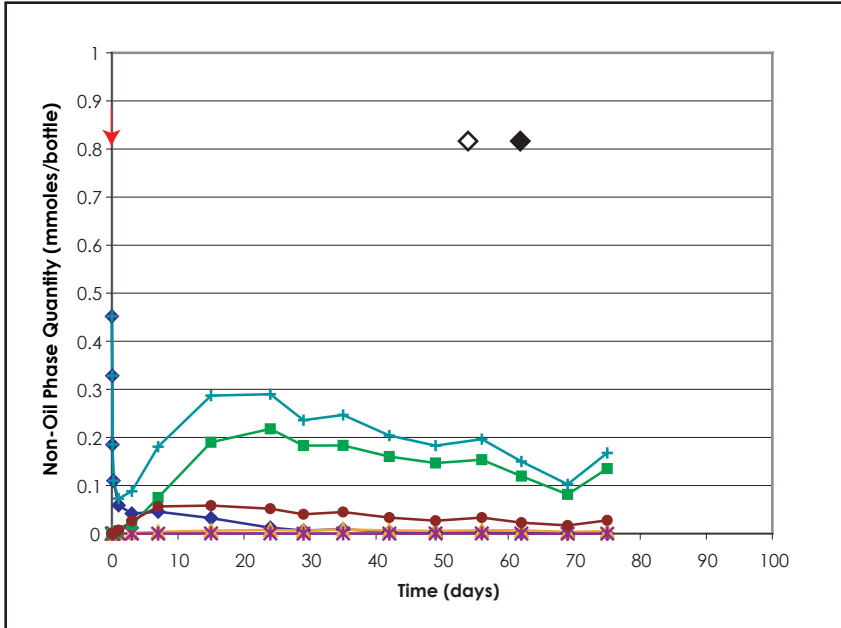
e) Sterile Zero Valent Iron and KB-1™



f) Emulsified Zero Valent Iron and KB-1™



g) Sterile Emulsified Zero Valent Iron and KB-1™



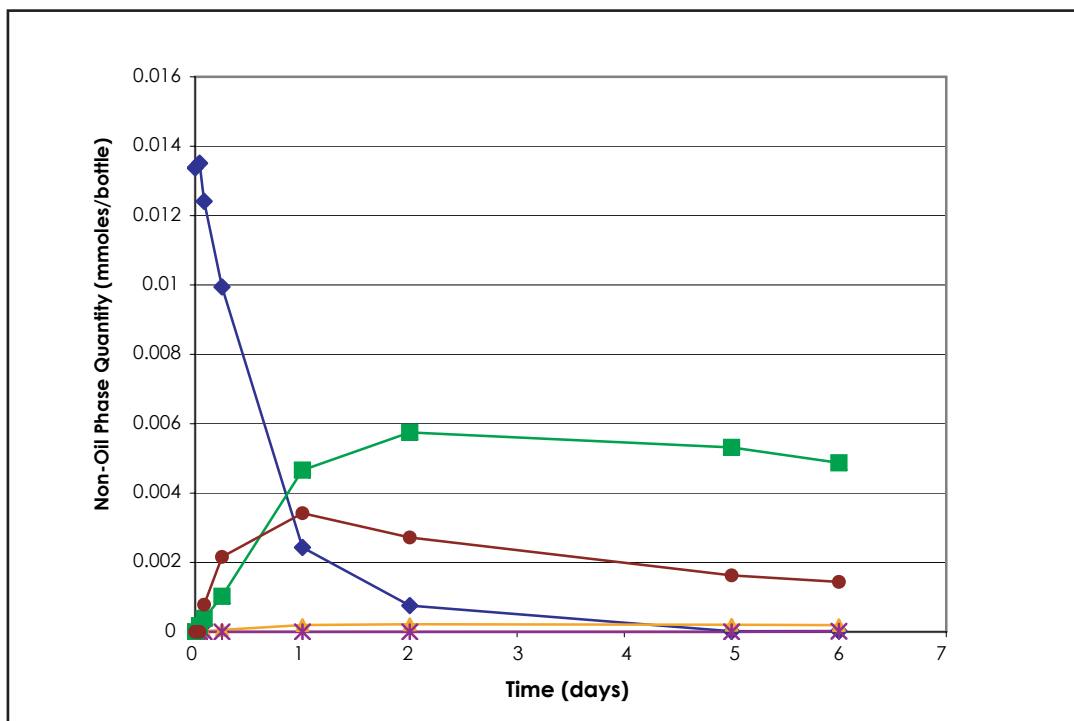
Dissolved Phase TCE Treatment Tests
Emulsified Zero-Valent Iron Laboratory
Treatability Study

Aug. 2005

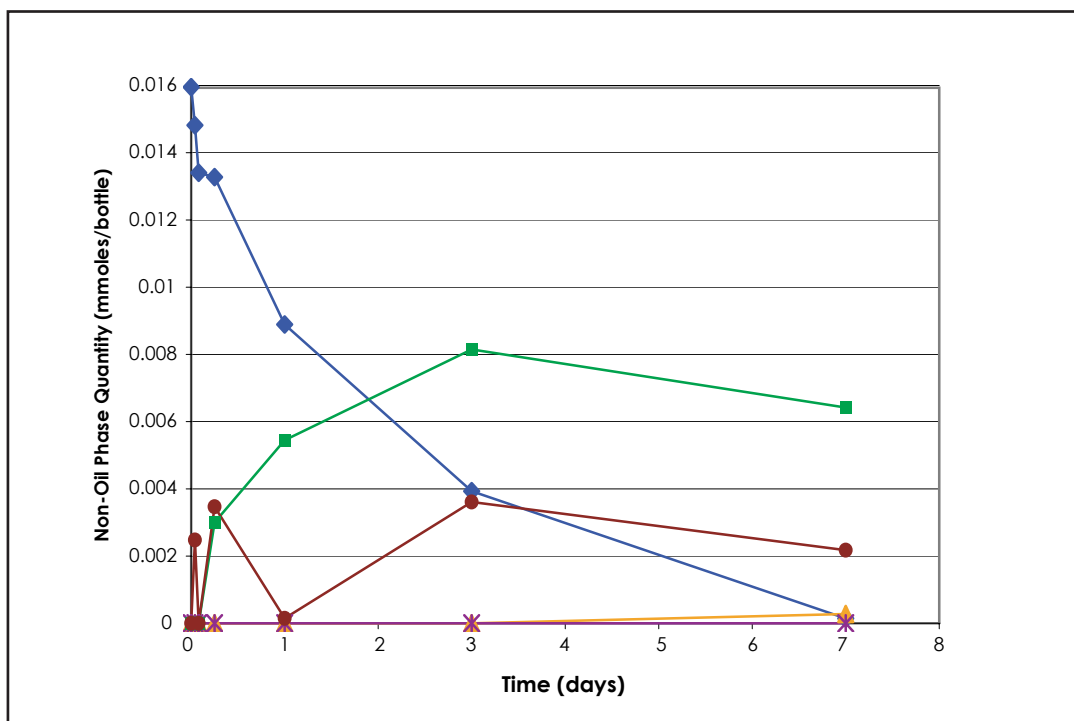
Figure: 2



a) Activity Assay for Dissolved Phase Testing (December 2004)



b) Activity Assay for DNAPL Phase Testing (February 2005)



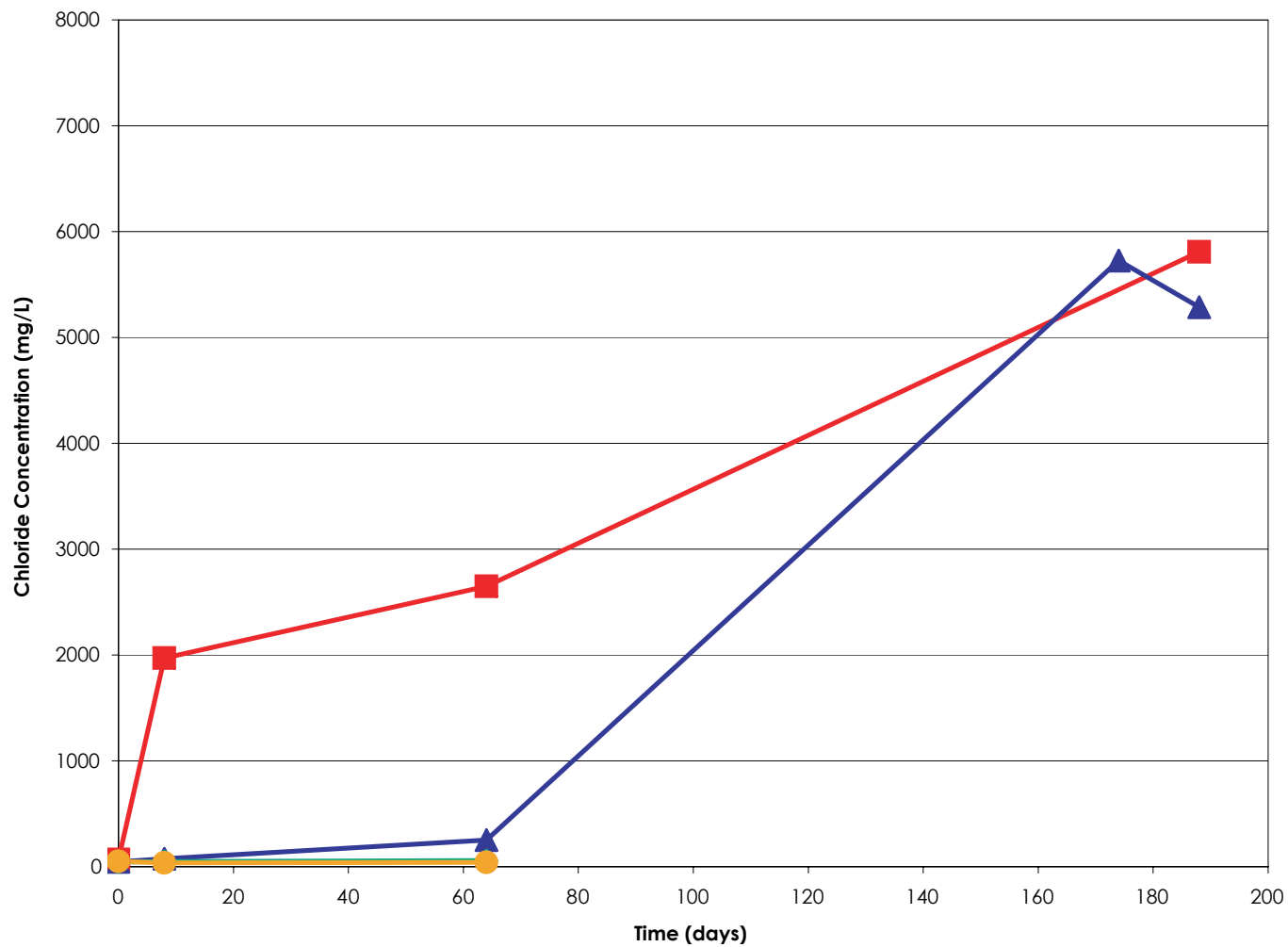
- ◆ TCE
- ▲ cis-1,2-DCE
- * VC
- Ethene
- Ethane

Results of nZVI Activity Assays
Emulsified Zero-Valent Iron
Laboratory Treatability Study

Aug. 2005

Figure: 1





—■— ZVI
—▲— EZVI
—◆— Oil
—●— Control

**Chloride Concentrations During
DNAPL TCE Treatment Tests**
Emulsified Zero-Valent Iron Laboratory
Treatability Studies

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Figure: 5

